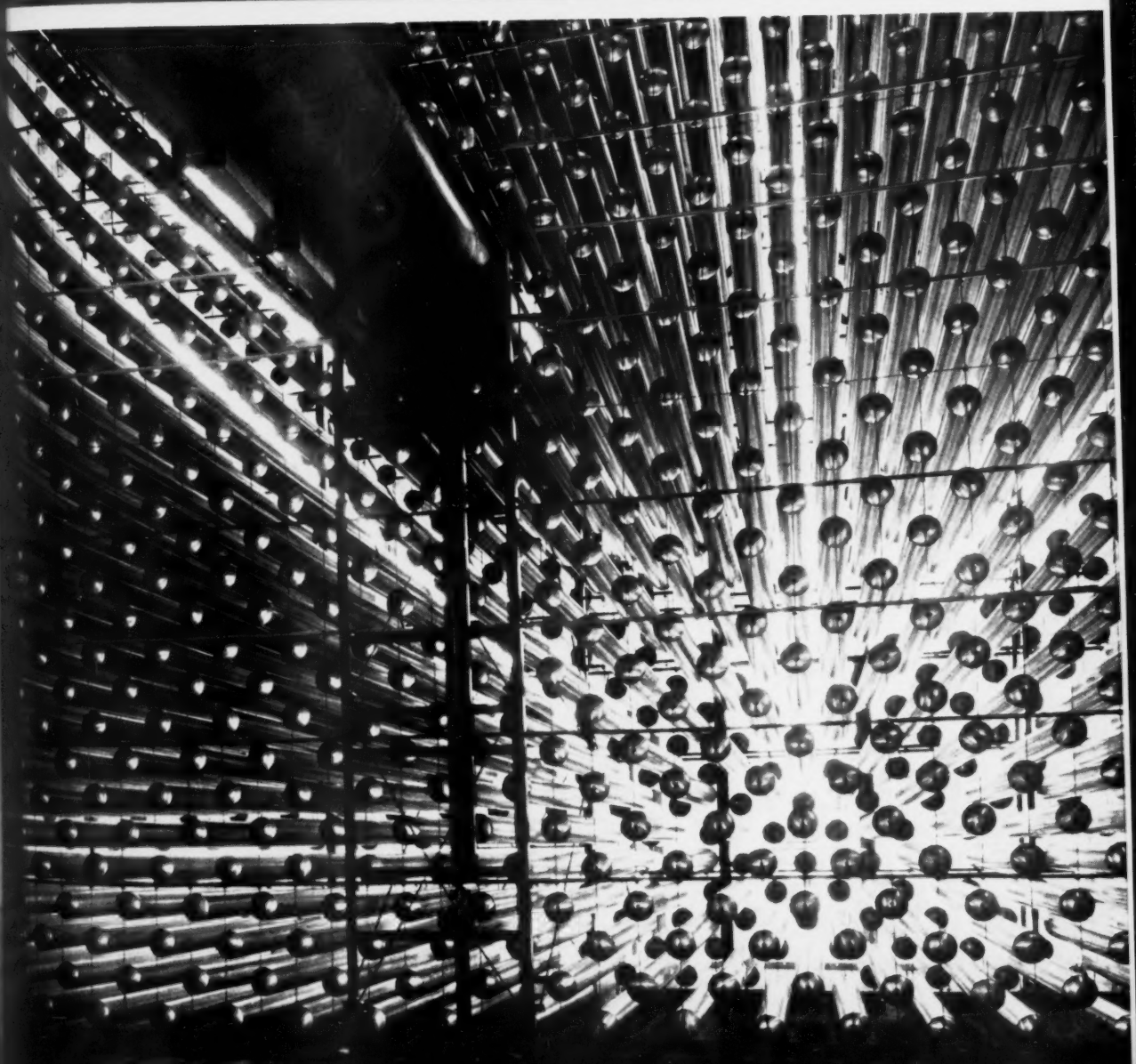
AERONAUTICAL ENGINEERING REVIEW

JULY 1951



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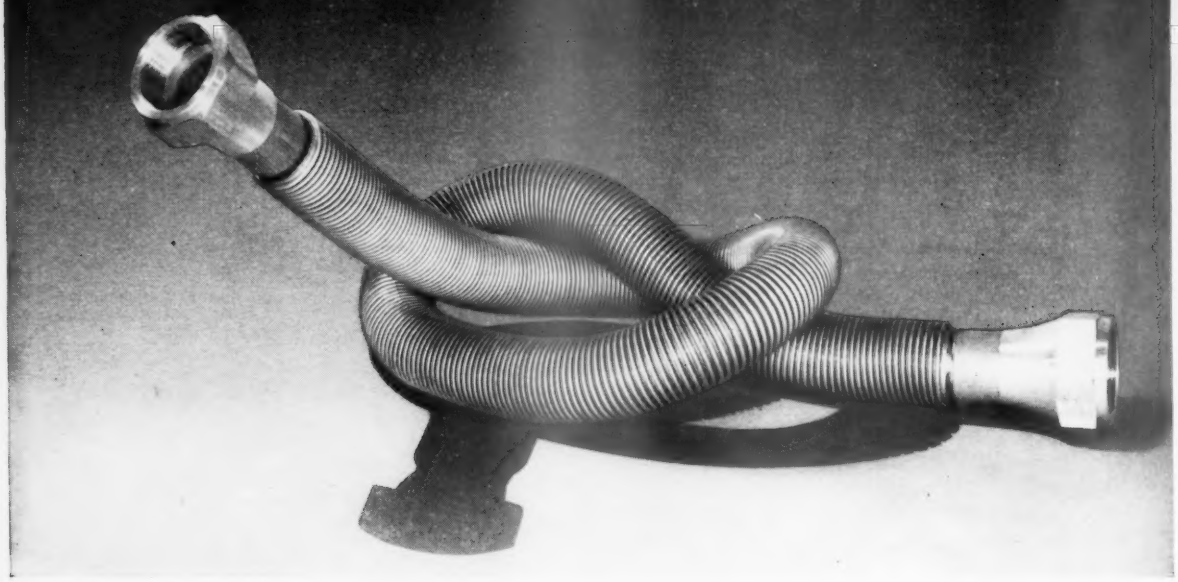

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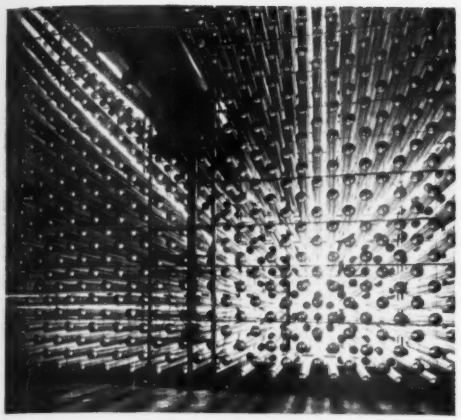

Cover—A bank of the Janke P4-DEE Fiberglas-lined units at the intake end of a test cell at the Caldwell, N. J., plant of the Propeller Division, Curtiss-Wright Corporation.

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AERONAUTICAL ENGINEERING REVIEW

Vol. 10 **JULY, 1951** **No. 7**

Contents

I.A.S. News 5

Guest Editorial—Technical Progress and Air Power in the World Crisis . . . . . L. B. Richardson 10

Articles

General Aspects of Cabin Pressurization . . . . . R. W. Rummel 14

Variation in Airplane Range with Wind Velocity . . . . . Robert E. Hage 18

Some Special Aspects of Air Transport Safety . . . . . C. M. Christenson 23

A Tested Solution of the Problem of Helicopter Stability and Automatic Control . Donald N. Meyers, Edward G. Vanderlip, and P. Halpert 27

Reviews

Aeronautical Reviews 63

Books 97

I.A.S. Preprints 60

Special I.A.S. Publications 108

Personnel Opportunities 109

Index to Advertisers 111

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I. A. S. News

A Record of People and Events of Interest to Institute Members

I.A.S. To Send Ninety Delegates to Third Anglo-American Aeronautical Conference

Plans for Technical Sessions at Brighton Finalized; Some Interesting Social Events As Well As Visits to Various Plants Scheduled for Second Week.

Major Frank B. Halford, President, Royal Aeronautical Society.

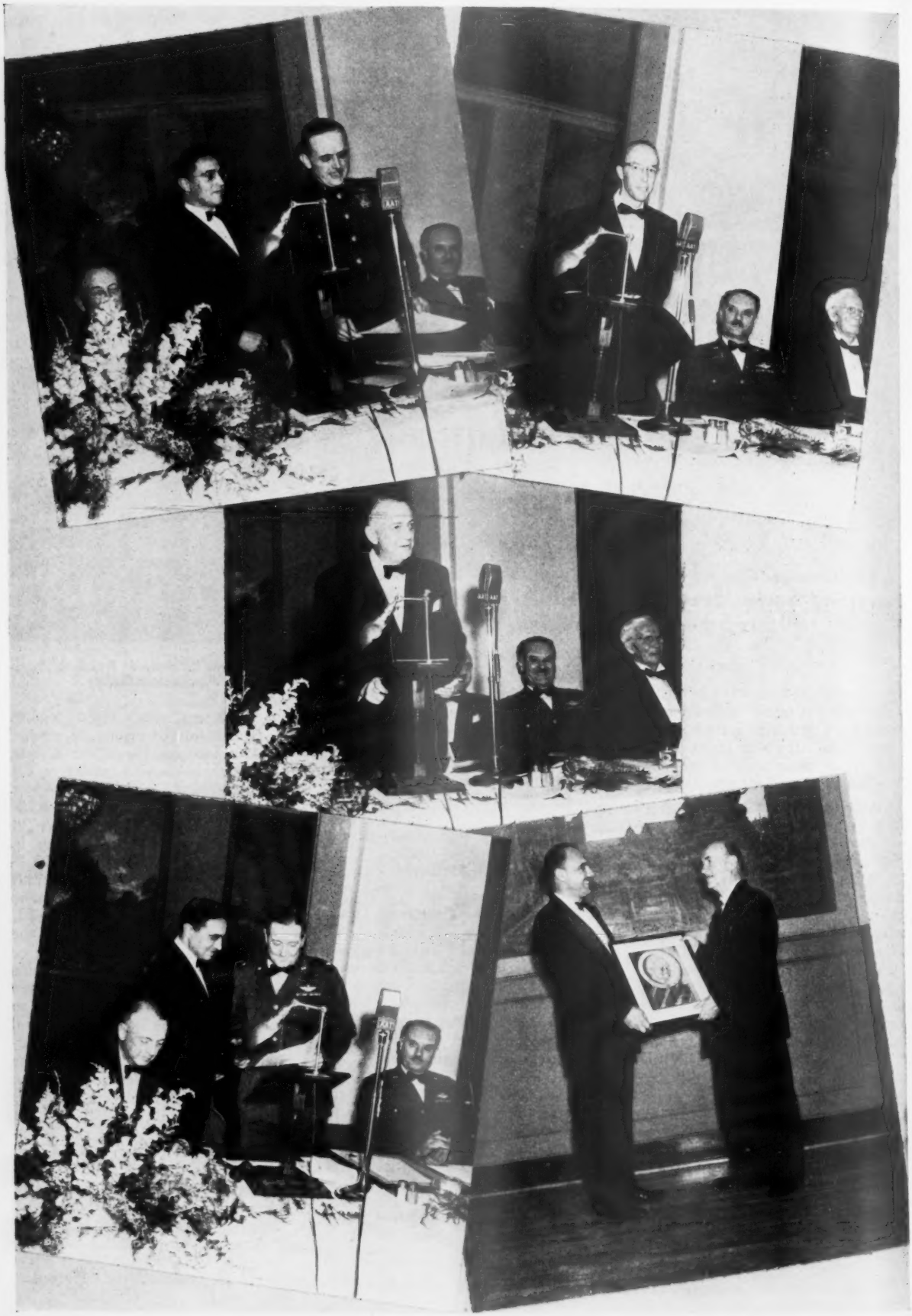
AN IMPORTANT CHAPTER in the furtherance of Anglo-American understanding will be written by those aeronautical engineers and scientists who will participate in the Third Joint R.Ae.S.-I.A.S. International Conference, which will begin its 2-week meeting with technical sessions from September 3 to 7 in Brighton, England.

Ninety delegates of the Institute of the Aeronautical Sciences, 35 of whom will travel with their wives, will converge on the maritime town of Brighton from all directions. A large group of them will fly in directly from America by either Pan American Airways or Trans World Airlines; a few more will utilize the facilities of the Military Air Transport Service. Others, showing a preference for a few days of sea air at sea level, will sail from New York on transatlantic steamers. The remaining members of the American contingent will already be in Europe and will journey thence over the English Channel to Brighton.

▸ **General Schedule**—The entire proceedings of the Third Anglo-American Conference will cover a 2-week period. The first week will be concerned with the presentation at the technical sessions of ten British and ten American papers, as outlined in the April, 1951, issue of the AERONAUTICAL ENGINEERING REVIEW. During the second week, the base of operations will be changed to London. From this point, visits to various firms and official establishments have been arranged for the edification of all concerned. On the intervening week end (September 8 and 9), a tour of the nearby English countryside—Oxford, Cambridge, and Stratford—is on the agenda.

▸ **Other Events**—Captain J. Laurence Pritchard and his staff at the Royal Aeronautical Society have gone to great efforts to ensure the ultimate success of this conference. As a result, a highly interesting and varied calendar of social events has been formulated. To the American, perhaps the most intriguing one of all will be the reception and dance given by the Mayor and Mayoress of Brighton for the conference delegates and their wives. It will be held on Wednesday, September 5, in the Royal Pavilion, a fantastic structure of Oriental design, complete with domes, minarets, and pinnacles, which was built as a royal palace for King George IV, then Prince of Wales.

In addition, two other social events of importance have already been arranged. One of these is the Conference Dinner, which will be held in the Grand Hotel on Friday, September 7. The other one, the Wilbur Wright Lecture, takes place in London on the next Monday and will be followed by a reception at the Royal Aeronautical Society building. The Wilbur Wright Lecturer this year will be Arthur E. Raymond, Vice-President and Director—Engineering, Douglas Aircraft Company, Inc. On evenings, when no particular function has been scheduled, delegates will be free to attend the theaters of London and Brighton or the Festival of Britain. Special trains are to be added to the London-Brighton run, so that there will be no need to rush an evening to a hurried conclusion.

▸ **Substitutions**—Applications for appointments as I.A.S. delegates to the Anglo-American Conference have been officially closed. However, there is always the possibility that one or more of the appointed delegates will be unable to attend for personal reasons. In this event, it would become necessary to select one or more "substitute" delegates from a "waiting list." Therefore, any I.A.S. member who is an American citizen and who would care to add his name to this waiting list please contact the Institute's Secretary.

Helicopter Society News

1951 A.H.S. Forum Whirls to Successful Conclusion

THE SEVENTH ANNUAL FORUM of the American Helicopter Society which took place on April 26–29 in Washington, D.C., proved to be the most successful meeting yet undertaken. In previous years, these forums have been held in Philadelphia. This year, however, the District of Columbia was selected in order to expedite the attendance of military personnel stationed in and around the Nation's Capitol.

On April 26 and 27, technical sessions on Theory and Design, Development and Test, and Economics, as well as symposia on Commerical and Military Operations, convened at the Forum's Headquarters in the Hotel Washington. The final 2 days brought the Seventh Annual Forum to a spectacular end with static displays and flight demonstrations of military and commercial helicopters.

The overall attendance exceeded that of any previous year. Over 300 industry members registered for the two-day technical sessions. Nearly 400 diners were present at the Honors Night Banquet on April 26, and approximately 200 attended the Pioneers' Dinner on the following evening. The helicopter demonstrations drew an estimated crowd of 12,000 persons.

Bartram Kelley, Chief Helicopter Engineer, Bell Aircraft Corporation, as Forum Chairman was in charge of the arrangements for this year's event.

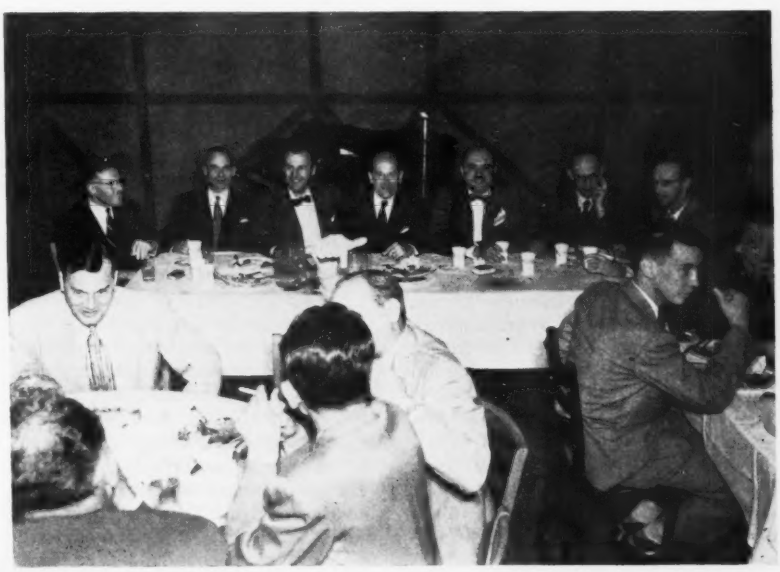
▸ **Honors Night Banquet**—The high point of the Seventh Annual Forum was the Honors Night Banquet at which The Honorable Dan A. Kimball, Under Secretary of the Navy, was the guest speaker. The outgoing A.H.S. President, Frank N. Piasecki, Chairman of the Board, Piasecki Helicopter Corporation, was the Chairman of the banquet. Dinner music was furnished by the U.S. Air Force Band under the leadership of Sgt. Lowell Smith. The dinner was held in the Hall of Nations Ballroom of the Hotel Washington.

In his speech, Mr. Kimball praised the performances of the various helicopters that are now making history in Korea and read letters from the Korean battlefront which gave appreciative testimony of the helicopter's valuable service rendered in observation, reconnaissance, target spotting, supply, and evacuation of the wounded. The speaker foresaw an even greater expansion in the use of the rotary-wing aircraft, stating that it has "become the jeep of the Korean war."

The Honors Night Banquet, as its name implies, was the scene of the presentation of certain honors. The Society's highest award, The Dr. Alexander Klemin Award, was presented to Igor I. Sikorsky, Engineering Manager, Sikorsky Aircraft Division of United Aircraft Corporation. The citation read: "for notable achievement in the advancement of rotary-wing aeronautics." The Dr. Alexander Klemin Award was established in 1951 by Mr. Piasecki to honor the memory of the late eminent aeronautical engineer, educator, author, and pioneer in rotary-wing aircraft. Col. Richard T. Kight, U.S.A.F., Commanding Officer, Air Rescue Service, Military Air Transport Service, was the recipient of The Captain William J. Kossler Award. The Kossler Award, established to honor the memory of the late U.S. Coast Guard aviator, aeronautical engineer, and early advocate of helicopters for Coast Guard operations, was presented to Colonel Kight "for greatest achievement in practical application or operation of rotary-wing aircraft, the value of which has been demonstrated in actual service during the preceding year." An Honorary Fellowship in the American Helicopter Society was extended to Brig. Gen. Clayton C. Jerome, U.S.M.C., Director of Aviation and Assistant Commandant of the Marine Corps for Air, in recognition of his "notable and meritorious service in the advancement of rotary-wing aircraft."

The A.H.S. banquet was concluded by the induction of the 1951–1952 slate of officers: Mr. Kelley succeeded Mr. Piasecki to the A.H.S. Presidency. Jean Ross Howard, Aircraft Industries Association, and Monroe Brown, Piasecki Helicopter Corporation, were inducted as Secretary and Treasurer, respectively. The following persons

FUN WITH THE PIONEERS: *April 27 at 8:00 p.m. was the time and O'Donnell's Farm in Forestville, Md., was the place of this year's laugh-getting Pioneers' Dinner. This picture of the head table was snapped during a more sedate period of the evening—before the Toastmaster went to work. At the center of the head table is Paul Thomas, whose antics as the evening's Toastmaster had nearly all of the diners "rolling in the aisles."*



RANDOM SHOTS AT HONORS NIGHT BANQUET: *Upper left—R. Allen Price (left), A.H.S. Vice-President for Great Lakes Region, presents Brig. Gen. Clayton C. Jerome, U.S.M.C., with A.H.S. Honorary Fellowship for 1950. Upper right—Bartram Kelley, 1951 A.H.S. President, gives his induction address. Center—The Honorable Dan A. Kimball, Under Secretary of the Navy, who was the guest speaker of the banquet, talks on the helicopter in Korea. Lower left—Col. Richard T. Kight, U.S.A.F., receives The Captain William J. Kossler Award from R. Allen Price. Lower right—Frank N. Piasecki (left), outgoing A.H.S. President, presents The Dr. Alexander Klemin Award to Igor I. Sikorsky.*

took office as Regional Vice-Presidents: for the Northeast, D. D. Viner, Sikorsky Aircraft Division, United Aircraft Corporation; for the East, T. R. Pierpoint, Piasecki; for the Great Lakes, R. Allen Price, Parsons Corporation's Aviation Division and Stanley Aircraft Corporation; for the South, Tom Wilson, Chief of Army Ordnance's Rotary Wing Division, Washington; for the Midwest, Charles R. Wood, McDonnell Aircraft Corporation; and for the West Coast, Clarence Belinn, Los Angeles Airways.

Bart Kelley, A.H.S. President, received his M.A. degree from Harvard University in 1934 and served for a time as a Mathematics Instructor at the Choate School and at Phillips Academy. He holds a private helicopter's rating and has logged over 135 hours. A native of Rosemont, Pa., he first came to Bell Aircraft in 1941 as a Helicopter Development Engineer.

Seated at the head table at the Honors Night Banquet were: R. Allen Price; Charles Kaman; Col. Richard T. Kight, U.S.A.F.; Brig. Gen. F. H. Lamson-Scribner, U.S.M.C.; Vice-Adm. E. S. Land, U.S.N. (Ret.); Hon. Lindley Beckworth, Congressman; Brig. Gen. Clayton C. Jerome, U.S.M.C.; Harvey Gaylord; Clarence Belinn; Rear Adm. C. M. Bolster, U.S.N.; Lt. Gen. M. H. Silverthorn, U.S.M.C.; Igor I. Sikorsky; Hon. Robert Crosser, Congressman; Frank N. Piasecki; Hon. Dan A. Kimball; Bartram Kelley; Maj. Gen. James Gavin, U.S.A.; Adm. Dewitt C. Ramsey, U.S.N. (Ret.); Hon. J. F. Floberg, Navy Assistant Secretary for Air; Fred M. Glass; Lt. Gen. Franklin A. Hart, U.S.M.C.; D. W. Nyrop; Hon. Carl Hinshaw, Congressman; Maj. Gen. D. L. Putt, U.S.A.F.; B. L. Whelan; Dr. Hugh L. Dryden; Maj. Gen. Floyd L. Parks, U.S.A.; Robert S. Burgess, Post Office; and S. Paul Johnston, I.A.S. Director.

▶ **Helicopter Exhibitions**—Fifteen helicopters from the military services "polka dotted" the skies over Washington, D.C., on April 28–29 in what was one of the largest formations of rotary-wing aircraft ever to fly over an American city. The helicopters flew at an altitude of 500 ft. from Hains Point north to Silver Springs, Md., west to Bethesda, Md., south to Georgetown, D.C., and back to Hains Point. After a public inspection, the craft took off for the Anacostia Naval Air Station where they were put through their paces by top pilots from the Marine Corps, Navy, Coast Guard, Army, and Air Force. Helicopters directly from Bell, Piasecki, and Sikorsky also demonstrated their potentialities.

The flight program was under the supervision of Brig. Gen. F. H. Lamson-Scribner, U.S.M.C., with the assistance of other military personnel. Lt. Comdr. William Bryson, Public Information Officer of the Navy's Bureau of Aeronautics, in cooperation with officers from the other services, handled the publicity arrangements. Lt. Comdr. Wayne Pomfrey, P.I.O. at Anacostia, arranged for the handling of the crowds attending and the helicopters participating in the exhibition of flying.

Through the generous cooperation of the helicopter manufacturers, military services, and A.H.S. and I.A.S. Officers, Forum Committee members, and the general membership, the Seventh Annual Forum will not soon be forgotten, but it is destined to linger on in the minds of those persons who were privileged to hear and see the latest trends and developments in the helicopter industry.

I.A.S. General News

Cargo Carrier Concern Joins I.A.S.

Seaboard & Western Airlines, Inc., has added its name to the evergrowing list of corporations that have taken up membership in the Institute of the Aeronautical Sciences.

Seaboard & Western, a registered irregular common carrier of international air freight between the United States, Europe, and the Middle East, was incorporated in September, 1946, by a small group of founders, all of whom served as pilots and in various executive and staff capacities with the Air Transport Command during World War II.

Flight operations with DC-4 equipment adapted to all-freight carriage were begun in May, 1947, and in the ensuing 47 months, through March, 1951, the company carried approximately 27,000,000 ton-miles of freight and flew 8,500,000 revenue miles, involving nearly 1,600 ocean crossings.

Seaboard's equipment now includes seven DC-4 aircraft, each capable of lifting more than 15,000 lbs. of pay load over the critical North Atlantic leg. As a noncertificated air carrier, Seaboard has been required to maintain a flight pattern of "infrequency and irregularity" in commercial operations. Its application for a certificate of public convenience and necessity authorizing unlimited air-freight operations to the areas it now serves irregularly has been heard by the Civil Aeronautics Board and a decision is awaited.

A pioneer of bulk freight carriage, a substantial part of Seaboard's business has included full aircraft loads of cattle; aircraft, automotive, and ship parts up to 7.25 tons in single shipments; race horses; helicopters; small aircraft; and motor vehicles. Early in its operations, it set a westbound North Atlantic freight record of 15,384 lbs. and an eastbound record of 15,539 lbs.

In two national emergencies, Seaboard is recorded as having been the first carrier to supply logistic airlift to the Military Air Transport Service under contract to the U.S. Air Force. The first was on the occasion of the Russian blockade of Berlin in 1948, during the first 6 months of which Seaboard made 106 North Atlantic freight flights with engines and critical parts for aircraft flying the Frankfurt-Berlin shuttle. The second arose with the Communist invasion of South Korea when Seaboard landed an airplane in Japan 5 days after the first U.S. troops landed in Korea; through February, 1951, over 360 crossings of the Pacific were made with more than 4,250,000 lbs. of war materiel and personnel.

I.A.S. Student Branches Hold Second Annual Southeastern Regional Meeting

The University of Florida Student Branch of the Institute of the Aeronautical Sciences in cooperation with Florida's Department of Aeronautical Engineering were hosts on April 13 and 14 to those 80 persons who attended the Second Annual Southeastern Regional Meeting of the I.A.S. Student Branches. Five Southeastern institutions were represented there—viz., Georgia Institute of Technology, University of Alabama (who was last year's host), Louisiana State University, Mississippi State College, and Alabama Polytechnic Institute.

There were three technical sessions during the two-day meet. Presiding at the first of these three sessions on Friday morning, April 13, was Costa Francisco, University of Florida's I.A.S. Student Branch Chairman. Six student papers were presented on this occasion; they

included: "Titanium and Its Use in the Aircraft Industry," by a University of Alabama student; "Efficiency Possibilities of the Turboprop Engine," by Charles Carter, Georgia Tech; "An Investigation of Anomalous Aileron Behavior," by Fred Obarr, Mississippi State; "International Agreements on Air Transportation," by Frank E. Rooks, Alabama Polytechnic; "Effects of Varying Plate Temperature on the Boundary-Layer Velocity Distribution," by a University of Alabama student; and "Ram-Jet Engines," by Perry Stern, Louisiana State.

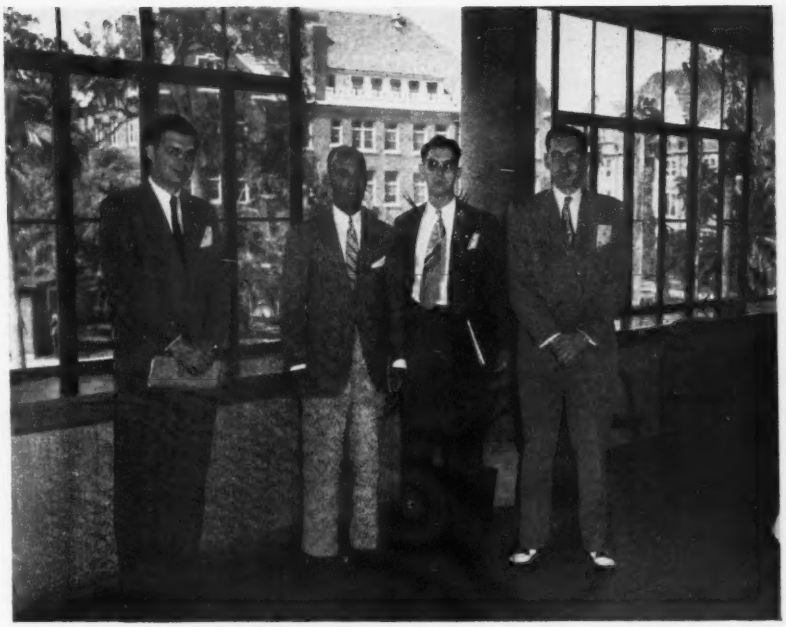
The Friday afternoon session was begun by a luncheon at which R. A. Thompson, Head Professor of Aeronautical Engineering, University of Florida, was the master of ceremonies. Grover Loening, noted N.A.C.A. Aircraft Consultant, who gave an address on the "Development of Air Transport," pointed out that things may not be as impossible as they appear and that one should continually re-examine old ideas to see if they are adaptable to new developments. Citing that it took about 10 years to overcome the resistance to monoplane construction, wheel brakes, and variable pitch propellers, Mr. Loening emphasized that aviation has developed so rapidly that we must always keep one jump ahead. He discussed further the possibilities of development in the fields of crash protection, gust alleviation, convertaplanes, and induced air flow by use of jet engines and pointed out that, in aviation, speed always pays off.

Mr. Loening's excellent contribution to the overall success of the Second Annual Southeastern Regional Meeting was followed by two faculty papers presented by Dr. August Raspet, Research Associate, Mississippi State, and by Prof. Hurlbut W. S. LaVier, Daniel Guggenheim School of Aeronautics, Georgia Tech. These papers were respectively entitled "Influence of Systematic Variations on the Drag Polar of the Sail Plane RJ-5" and "Georgia Tech Water Table As a Supersonic Flow Analogue." Ross D. Reitz was chairman of this part.

On Friday evening, under the leadership of Blake W. Lambert, a banquet was held at the Gainsville Golf and Country Club. N. H. Bullard, assisted by Mr. Dillon, gave a lecture and an accompanying film on the Long Range Proving Ground at Banana River, Fla. The final address of the evening was given by Capt. Gail Halvorsen, a University of Florida senior, who discussed the Berlin Airlift and presented a film on the Airlift taken during his assignment there.

James R. Carter led the morning session on Saturday, April 14. Prof. W. G. Sherling, Alabama Polytechnic, presented a faculty paper on "Plasticity for the Aeronautical Engineers"; Prof. Joseph J. Cornish, Mississippi State, gave another on "The Electronic Stethoscope, a New Instrument for Turbulence Studies"; Mr. Dillon, of the Joint Long Range Proving Ground, discussed "Job Opportunities."

During the business meeting that concluded the technical sessions, it was decided that the host for the next conference in 1952 would be Georgia Institute of Technology. Costa Francisco presided.



Grover Loening Speaker at Student Conference: *Shown in the foyer of the University of Florida's Student Service Center are: Prof. R. A. Thompson, Head, Aeronautical Engineering Department, University of Florida; Grover Loening, Luncheon Speaker; Costa Francisco, I.A.S. Student Branch Chairman, University of Florida; V. G. Polovkas, Instructor, Aeronautical Engineering Department, University of Florida. The occasion was the luncheon given on the first day of the Second Annual Southeastern Regional Meeting of the I.A.S. Student Branches.*

Office of Air Research Lets Oil-Film Contract

Dr. Burt L. Newkirk, A.F.I.A.S., and Rensselaer Polytechnic Institute have been awarded a $24,560 contract for a 2-year study of instability in oil films on journal bearings. Associated with Dr. Newkirk in this project is John F. Lewis, I.A.S. Student Member.

Being constructed by Dr. Newkirk and Mr. Lewis is a solidly based concrete pier in the basement of the Winslow building as a mount for a 4-ft. shaft that will turn the various types of bearings to be studied. Oils at varying temperature and viscosity levels will be used in the bearings; vibration readings will be taken from the shaft ends.

Dr. Newkirk first became interested in machine vibrations arising from the instability of oil films in bearings in 1925 while he was working with an experimental group in the General Electric Company laboratories in Schenectady. This present research project is believed to be the first effort to correlate oil-film whirl closely with the hydrodynamic theory of lubrication.

Dr. Newkirk is Professor Emeritus of Vibration Theory and Practice in aeronautical engineering at Rensselaer. Mr. Lewis is an R.P.I. Graduate Student in aeronautical engineering.

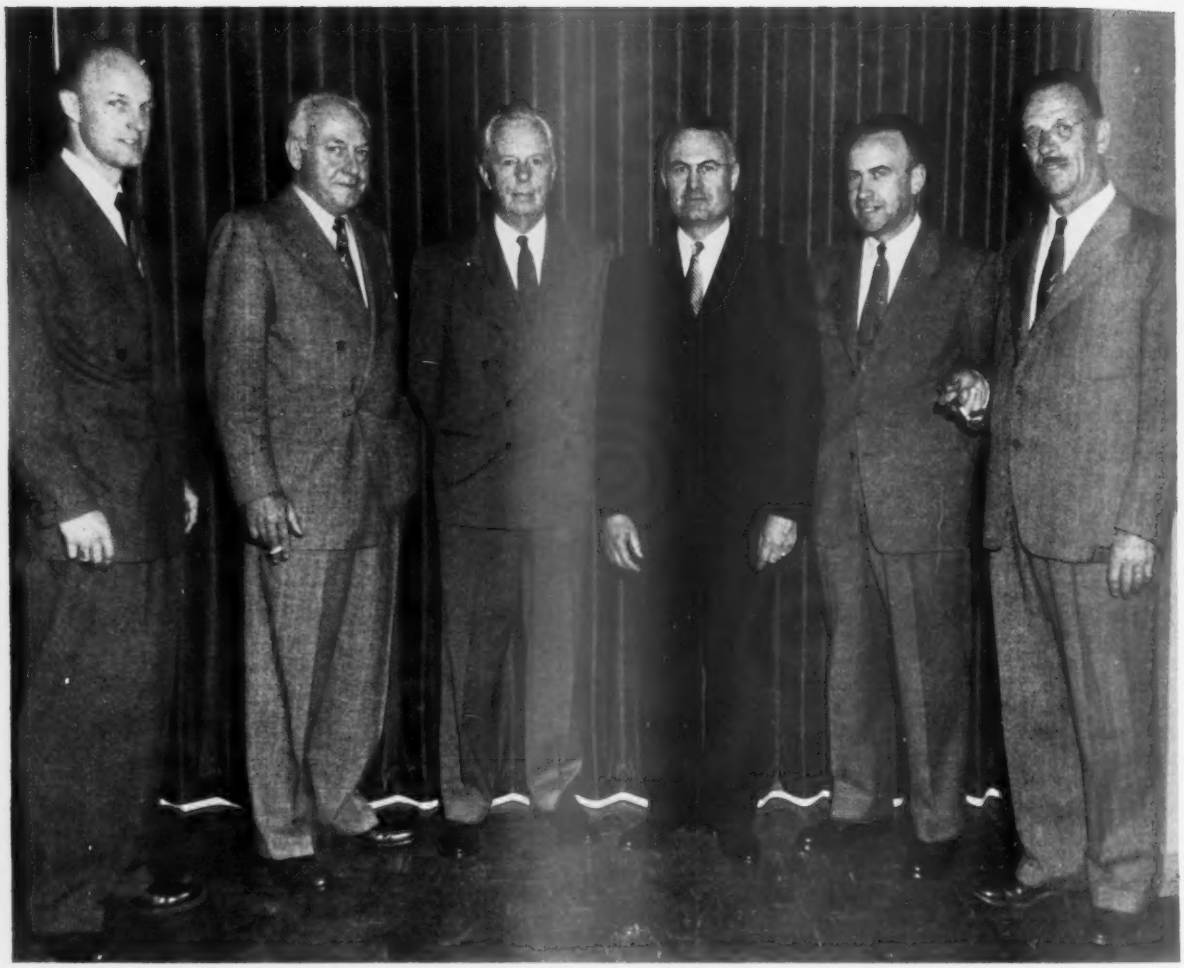
Case Institute Expands Engineering Program

Case Institute of Technology announces the expansion of its graduate curriculum in the aeronautical engineering field. Accordingly, a Ph.D. degree and a Master's degree are being offered in aerodynamics and aircraft propulsion.

Courses comprising an aeronautical major include sequences in compressible and incompressible flow theory, viscous flow theory, jet propulsion, and compressor and turbine work. In addition to courses in advanced mathematics and physics, newer offerings are available in servomechanisms and control.

The completeness of this program at Case is made possible through the cooperation of N.A.C.A.'s Lewis Flight Propulsion Laboratory in Cleveland. Several Case courses are instructed by N.A.C.A. research scientists who are specialists in their given fields.

(*Continued on page 35*)



Technical Progress and

"THERE HAS BEEN THOROUGH COVERAGE of the subject of air power, including books by people far more erudite than I; much has also been said about technical progress as it affects air power. However, the combination of these things with the current world crisis and their relation to it have not been discussed to any great extent. These are the subjects on which I shall offer a few thoughts.

"This so-called world crisis will probably be with us so long that it will become almost a permanent condition. All indications are that we should accept the situation, accustom ourselves to it, and settle down to long-range plans, policies, and programs on that basis. The need for technical progress in everything connected with aviation has been sharpened by the crisis. Whether the world situation continues to be 'cold war,' whether the Korean war spreads, or even if the 'shooting war' subsides for a time, this nation must not relax its all-out determination to win this international contest for qualitative superiority in the air!

"We fought the last war with aircraft whose basic designs had been completed and whose development had begun before we entered the war. This was not the case in many other fields of war material (developed under Office of Scientific Research and Development sponsorship). In these other fields, new weapons, which were developed and put into service after we entered the war, affected its outcome decisively. One of the great lessons of that war was the significance of new weapons, but the record of aviation was unsatisfactory in this respect. We must be ready to do better the next time, and we should be examining the past and planning the future with that in mind.

"We should have had gas turbines (turbojets especially) in airplanes and in service during that war. The Germans did it, though in insufficient numbers and too late because of the gross mistakes of their dictator in his direction of development and because of his short-sighted allocations of technical effort.

Guest Editorial

by

*Rear Adm. L.B. Richardson, U.S.N. (Ret.)**
President, I.A.S.

Air Power in the World Crisis†

"Nevertheless, the Germans were ahead of us in supersonic aircraft and guided missiles (and their power plants) at the end of World War II. We have made good headway toward overcoming that handicap, and today we are probably at least abreast of anyone in the world. However, the presence of many German scientists and aeronautical engineers in Russia ever since early 1945 may mean that the Russians are ahead of us now, in some ways. Surely they are making strenuous efforts to excel us. We must be exceptionally careful, for this reason, not to let our rate of technical progress decrease.

"Our aeronautical programs in the last war were governed by a policy that approved only those things that would 'win this war.' Development and even research were not permitted on aeronautical projects that the high military authorities thought could not be completed in time to help win it. I believe this attitude and policy accounted for many missed opportunities for technical advancement and were largely responsible for the dearth of advanced scientific work in aeronautics during the war years.

"We must avoid that forced technical slow-down and standardizing or 'freezing' of designs which would be the result of a policy of limiting our efforts to those things believed to be far enough advanced to 'win this war.' This philosophy, in our present situation, would mean

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† An address delivered before the I.A.S. Los Angeles Section, April 19, 1951.

The photo on the opposite page shows Admiral Richardson with leading West Coast figures just before presentation of the lecture. Reading from left to right are: F. A. Cleveland, Los Angeles Section Chairman and Research Group Engineer, Preliminary Design Division, Lockheed Aircraft Corporation; J. H. Kindelberger, I.A.S. Past-President and Chairman of the Board, North American Aviation, Inc.; J. K. Northrop, I.A.S. Past-President and President, Northrop Aircraft, Inc.; Admiral Richardson; E. C. Wells, an I.A.S. Vice-President and Vice-President—Engineering, Boeing Airplane Company; and C. B. Millikan, Director, Guggenheim Aeronautical Laboratory, California Institute of Technology. *Photograph by Lawrence Weisman*

contenting ourselves with those things good enough to tide us over this crisis and good enough for a war if it comes within that ephemeral unit of time—'the foreseeable future.' We should not freeze types in the interest of quantity production under conditions of this 'crisis.' 'Freezing' of models of anything being produced in the United States is almost an automatic habit, but it would be a bad mistake to do so now with our airplanes. It is axiomatic that, in aerial warfare, the factor of quality is relatively more decisive than the factor of quantity.

"During the years 1942–1945, the N.A.C.A. was required, by the urgency of quantity programs, to concentrate its efforts on the improvement of aircraft and engines for production. Fundamental aeronautical research was almost abandoned. This was justified, because our total facilities and man power for aeronautical development were seriously inadequate, and there seemed to be no alternative except to push research out of the picture in favor of solving urgent week-by-week problems. It was a technical hand-to-mouth existence (or wind tunnel to assembly floor). N.A.C.A.'s effort was about 10 per cent research and 90 per cent specific development—the latter meaning mostly trouble-shooting—for four years. No doubt it had to be done to meet the demands of the war program, but it practically stopped the acquisition of new fundamental knowledge in aeronautical science. At the end of the war, we had no reservoir of such knowledge derived from research, and we had fallen behind in our solutions of the new and pressing scientific problems of high-speed, high-altitude flight.

"Immediately after the war, the N.A.C.A. vigorously advocated resumption of basic research and the freeing of its facilities from the accumulated backlog of development and improvement projects. With the cooperation of the Air Force and Navy, the N.A.C.A. programs were soon cleared by canceling the residue of such items, and the laboratories resumed their normal research functions rapidly and efficiently. The progress made by the N.A.C.A. in the last five years is, I think, truly remarkable. Its staff and laboratories are working with real effectiveness, performing a great service to the nation.

"The best authorities tell us we are facing a world crisis of long duration. Good judgment, then, dictates that our plans and policies must ensure technical progress such that the boundaries of knowledge gained from basic research will be kept always at a proper distance beyond the scope of current development and applied research and a good distance beyond the reach of any potential enemy.

"If we let technical progress lag during the forthcoming years of this crisis (How many years? Ten, as General Marshall thinks?), we are sure to fall far behind our probable enemies, for we cannot count on their being as mistaken in their development objectives as were the Nazis.

"The research successes thus far realized in the field of transonic aerodynamics strongly emphasize the need for continued intensive work to solve the many detailed problems that have been brought to light. These problems demand further experimental research in order that we may soon develop airplanes of all sizes for efficient operation through the transonic speed range. This is another example of the urgent necessity for progress and for policies that will promote prompt application of research results.

"Aeronautical development and general technical progress in aviation can move ahead only as they follow fundamental aeronautical research. Research must be continuous, but development should go ahead on a step-by-step 'project' basis. This will keep us ready at any time for production of the most modern service aircraft if a large-scale war program be suddenly thrust upon this nation, as leader and supporter of the free world.

"The fact that the only American airplanes that got into combat in World War II were those that were under development at the beginning of the war has been emphasized repeatedly by the services and by our industry. We thus have convinced ourselves, the Government, and, to a large extent, the public that a long time is needed to develop new airplanes and put them into production (4 to 7 years). We originally emphasized this condition chiefly in order to stimulate longer-range experimental programs and to awaken interest in planning further ahead for the orderly improvement of military airplanes as a whole. This effort has been successful, and there is general realization today that there are certain time requirements inherent in the whole procedure, from study phase to production delivery. However, let us never become reconciled to such slow progress as existed just prior to World War II. The total time requirements should be reduced, and they can be!

"The well-known and universally approved National Aeronautical Research Policy of March, 1946, assigned research to the N.A.C.A., development to the industry, and testing and evaluation to the Armed Forces. There is general agreement that we should keep these assignments intact, as far as it is reasonable to do so. However, we already see evidences of a resumption of the old practice of using N.A.C.A. research facilities for specific developments and for trouble-shooting to solve problems arising in the current expansion. This should not be allowed to grow into regular procedure! We must not undermine the research foundation on which our future technical progress will be built. This is especially important now, when we in the United States are practically 'on our own' in the research field and when we are facing an indefinite period of international tension. We have assumed global responsibilities that require us to assume technical leadership as well.

"The Air Force has begun the great Arnold Engineering Development Center, and we hope this will be pushed to early completion and operation. It undoubtedly will be operated with industry counsel and assistance, and we understand that it will be used to supplement industry's development work, not to sup-

plant it. Costly facilities of the kind being planned for this establishment are beyond the financial reach of industry. Primarily they are needed for testing and evaluation, but large scale developmental projects naturally will be included among their continuing activities to help industry in its mission.

"Our guided missiles programs should lead the world in the race for new developments. We beat the Germans in certain things—mainly in overwhelming quantities of standardized aircraft. The Germans beat us in guided missiles and in readiness of jet-propelled fighters, although these came 'too little and too late.' If they had come two years earlier—and in the quantities then possible—the war might have ended differently, or at least it would have dragged on much longer, while we changed our concept of what would win it!

"I believe we are not nearly as far along the development road in guided missiles as we should be. This seems to be due to a variety of causes, some already cured but others still persisting: controversies over cognizance and prerogatives, aggravated by some professional jealousies; too much money spent on calculations and studies and not enough on hardware and flight testing; shortage of test facilities; lack of sufficient scientific and engineering personnel in the Armed Services able to judge the merits of competing programs; and too theoretical an effort and too little practical work in the two years after the war.

"I think it is fair to say that overcoordination and control have hindered progress, too. A certain amount of competition in solving technical problems is constructive and generally expedites progress. In our guided missile programs of the past three years, too much emphasis has been placed on avoiding so-called 'duplication.' Allegations of widespread duplication have been made too often and too loosely by people who did not have that intimate knowledge of the subject which is essential before one can tell whether there really is unnecessary duplication. There is always the danger that overemphasis on coordination and control will cause the Armed Services to be satisfied with minor improvements and a slow rate of progress rather than the rapid attainment of major advances which is possible by the intelligent use of 'the parallel approach' to abstruse problems. Regimentation is bad for technical progress in new and unconventional fields.

"Electronics research and development now seem to be the most important need in the guided missile field. Guidance is the heart of our problem. Most other factors affecting guided missiles, whereby they are similar to supersonic airplanes—for example, aerodynamic (or 'aeroballistic') characteristics, stability and control, propulsion, structures, and aero-elastics—are, or can be, as well developed for the missile as for the airplane. But guidance is another matter, especially for long-range offensive missiles and for high-altitude target-seeking defensive missiles. In the guidance field, more emphasis on progress is truly needed.

"General Vandenberg said recently: 'We must still rely principally on men going up in machines to meet the enemy in direct combat.' We shall have to accept this situation until guidance of pilotless missiles is much further developed than at present.

"One major problem in the propulsion field, on which research and development progress must be speeded up, is that of materials for aircraft gas turbines. The announced production goal of 18,000 jet engines per month raises serious questions of material availability. We have an entirely new set of problems, because the enormous requirements for critical and strategic metals —cobalt, columbium, chromium and others—far exceed the obtainable supply. Research must find materials that will enable us to make substitutions without sacrifices in quality and performance. Delay in solving this dilemma could cause a serious bottleneck in the aircraft program.

"It is well known that jet engines suffer from high rates of fuel consumption. Good work has been done and is being done to improve this condition, and this progress must be accelerated by all possible methods. General Vandenberg says: 'Combat radius is the key to the advantage we hold in the air.' Holding this advantage for the near future will be chiefly dependent on finding ways to operate jet engines on less fuel per pound of thrust per minute.

"Radius (or range) so great as to be virtually unlimited will be a characteristic of nuclear-propelled airplanes, when these reach the operating phase. The principal problems involved in this method of airplane propulsion have been delineated, and approaches to solutions for many of these problems have been suggested. Solutions of the remaining problems now appear feasible, though, of course, extensive development and experimentation will be required. The achievement of nuclear-powered flight ahead of any other nation is clearly an objective that we must gain.

"True security consists of being as far as possible ahead of any potential enemy or any unfriendly competitor. We must rely on continuous technical progress to keep us well ahead. As Dr. Jerome Hunsaker says: 'The qualitative superiority of our air weapons is dependent on the degree to which we exploit scientific and technological talent.'

"To quote General Vandenberg once more: 'Air power alone does not guarantee America's security, but I believe it best exploits the nation's greatest asset—our technological skill.'

"Scientific skills and knowledge have become one of our most important national resources. The accumulation of scientific knowledge in the aeronautical field is probably the most vital resource, and on it depends technical progress in the last analysis.

"Scientific and engineering brains must be kept at work on research, development, and design. As Dr. Vannevar Bush said of development programs under his direction during the last war: 'We managed to maintain our staffs (of scientists and engineers) during the

(*Continued on page 22*)

General Aspects of
Cabin Pressurization

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IN THE SHORT SPAN OF 10 YEARS since T.W.A. placed its first pressurized commercial airplanes in service, pressurization has become not only an accepted standard of design but also a basic requirement for both the air transport industry and the military services. In this 10-year period, we, in the Industry, have learned much of cabin pressurization, and, since the next step forward to the jet- or turbine-powered transports will impose much more stringent design requirements, it is well that we review our past experience and reaffirm design precepts and goals. I shall not attempt to discuss the myriad details of pressurization design. However, since T.W.A. has been a leader in the operation of pressurized transports, I should like to review our past and present experience and, also, based on this experience, what we in T.W.A. will require for future aircraft. Before going further with this discussion, we should first restate the basic aims and goals for pressurized aircraft and determine how far along the road we have come and how much farther we have to go before reaching the ideal goal. In this regard, the basic pressurization requirements for transport airplanes consist of four major points. These are:

(1) Uppermost, we must design to achieve comfortization with an atmospheric environment equivalent to normal ground levels. In this connection, we mean the cabin must be kept as nearly as possible to sea-level conditions and that pressure fluctuations cannot be tolerated. Otherwise, people with marginal aerated ear conditions will still find flying uncomfortable. Furthermore, the pressurization system must include air-conditioning provisions and adequate circulating airflows.

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* Chief Engineer.

FIG. 1. Boeing 307 Stratoliner.

(2) Pressurization systems must be designed to provide this comfort level at the optimum operating altitude of the aircraft.

(3) Pressurization systems must be designed to provide this same comfort level but, at the same time, enable transport aircraft to operate over weather conditions, thereby assuring greater schedule reliability.

(4) Finally, and certainly not least, none of the foregoing design concepts can be achieved at the expense of compromising safety. Airplane structures, windows, and doors must be designed to be fail-proof against explosive decompression.

Now, let us look at what we have accomplished and what remains to be done in the field of pressurization. The first pressurized transport was the B-307 or Stratoliner (see Fig. 1), which was placed in commercial operation by T.W.A. in May, 1940, following a 3-year development. Mechanical compressors produced by the General Electric Company and engine driven by extension shafts were installed in Nos. 1 and 4 nacelles. The design pressure differential was an 8,000-ft. cabin altitude at a 15,000-ft. airplane altitude. Structurally, the fuselage design was of conventional barrel shape and was equipped with inward opening doors which alleviated the door-sealing problem. Initially, the B-307 was equipped with an automatic pressure control system, although this was later discarded in favor of a manual system because of maintenance and operational difficulties. Difficulties were also encountered with the drive shaft and supercharger itself, but, in retrospect, this is not too surprising considering the then existing state of development. This airplane remained in T.W.A. service until the past summer season, during which the fleet was retired from service because of economic obsolescence in our particular situation.

During the war years the airplanes were operated unpressurized, and, upon their return to T.W.A., pressurization equipment was not reinstalled because of material shortages. In lieu of pressurization, a hot-wall-heating system and a new ventilating system were designed by T.W.A. involving the development of a "package" heating and blower system that could be exchanged in the aircraft in an elapsed time of 20 min.

As far as is known, this was the first hot-wall-heating system placed in commercial operation, and it was most successful and well received by the public from the comfort point of view.

Following the B-307, the Model 049 Constellation was the next pressurized aircraft operated by T.W.A. (see Fig. 2). Design and development criteria were laid down during the summer of 1939. Because of the wartime delay, these aircraft were not placed in commercial operation until the fall of 1945. For the Constellation, the pressurization system general design is similar to the Stratoliner, in that cabin pressure is supplied by two remotely driven mechanical superchargers mounted in Zone 3 of Nos. 1 and 4 nacelles. Cabin pressure differentials had improved over the Boeing with an 8,000-ft. cabin pressure being supplied at a 20,000-ft. airplane altitude. Also, all doors are inward opening. These aircraft were initially equipped with an automatic pressure control system, but, as in the Stratoliner case, this system was later replaced by T.W.A. with a manual pressure control system, again because of maintenance and operational difficulties experienced with the automatic system. One of the chronic difficulties experienced was wide, unexpected variations in cabin pressure which caused some annoyance and occasionally discomfort to the passengers. Later series of Constellation aircraft do have automatic controls that provide an improved comfort level, but controls must be designed to hold pressure fluctuations to even closer tolerances. Considerable mechanical difficulty was experienced with the drive shafts which re-emphasized the need for, and prompted the installation of, oil temperature and bearing warning signal devices, as well as numerous mechanical improvements. The supercharger units were developed further as experience was obtained, gradually resulting in allowable increased overhaul periods and reduction in operating costs.

Both the Boeing 307 and early Constellation experience confirmed the need for cabin cooling systems in pressurized passenger-carrying aircraft. The Constellation was initially engineered with a mechanical-type refrigerating system, but this development was stopped during the early war years. Modifications to these aircraft to provide cooling would be extensive and expensive and, to be most effective, would involve changes to the heat exchangers, engine drive pads, compressors, wing ducting, and cabin distribution system, as well as installation of the cooling equipment. Consequently, the 049 aircraft does not have refrigeration, although installation of it is under consideration.

Development of the air-cycle system of refrigeration during the war years permitted a lightweight (but power-consuming) system to be evolved for the postwar series of Constellation airplanes. This system, performance-wise, has been reasonable as long as the engine-driven superchargers are operating at near maximum output. Practical engine r.p.m. limitations during taxiing periods and during periods of protracted holding on a hot day on the runway can limit cooling performance with the air-cycle system. The variable speed drive aids in this but does not seem to offer a complete solution since cooling is still marginal.

Also needed and long sought after was the mechanical supercharger disconnect to permit decommissioning a malfunctioning supercharger without requiring feathering. Such a unit is now in use and, although suffering

FIG. 2. Model 049 Constellation.

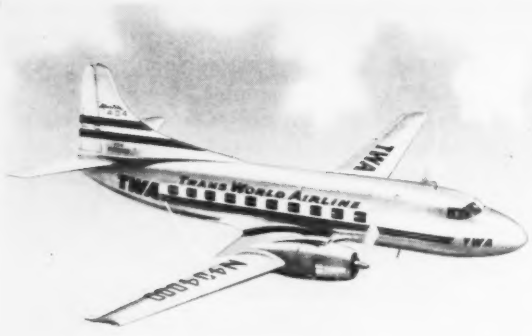

FIG. 3. The Martin 4-0-4.

some "growing pains," seems generally to be satisfactory.

During the war, T.W.A. and other air lines undertook many engineering investigations and, in some cases, actual developments to aid in the preparation of design and performance specifications for the postwar transports. In our case, investigations concerned, for example: electrically driven variable-speed superchargers; cabin compressors driven by small internal combustion engines mounted aft of the pressure bulkhead, using exhausted cabin air for a supercharged combustion air source; hydraulically driven units; and directly driven engine-mounted units. The electrically driven system was abandoned because of weight, and the auxiliary-engine-driven unit was dropped because of lack of a suitable engine and lack of a suitable airplane in which to install such a device, since it was also planned to use the auxiliary engines for electrical power. Hydraulically driven units are now practical and are in operation on some types of aircraft, although not in T.W.A. service. With its relative simplicity and lack of an extension drive shaft, the engine-mounted supercharger, such as is currently planned for the Martin 4-0-4 airplane (see Fig. 3) and which as a general type has already been installed in some Convair-Liners, is believed to offer considerable promise in the direction of reduced operating costs. To supply better cooling during taxiing and holding periods at the end of the runway, the AiResearch unit to be installed in the Martin 4-0-4 will be equipped with a gearshift type mechanism, which will permit optimum cooling output at low engine r.p.m. This results in higher drive torque requirements than the nongearshift arrangement and requires some modification and strengthening of the engine drive mechanism. (A similar shifting arrangement is also employed on later Constellation-type aircraft, but in some cases full refrigeration cannot be realized during extended ground operation because the engine drive pads have not been reinforced to withstand the refrigeration torque requirements.) Cabin altitude is maintained automatically at the selected level, and manual override equipment is also provided. It is anticipated, and we hope experience will substantiate, that elimination of the extension shaft is a step forward.

From a dollars and cents standpoint, pressurization has been a costly venture, although not without some tangible rewards. For example, our Constellation compressors cost approximately $1,400 per unit to overhaul. Compare this with a cost of $2,700 to overhaul an R2000 engine used on the DC-4. From an operating standpoint and including such items as additional fuel, overhaul and maintenance expenses, amortization, and even window replacements, the cost of maintaining the pressurization system on the Constellation is approximately $4.94 per flight-hour or 2 cents per mile. On the Constellation airplane, however, offsetting these costs, is the ability to operate at higher altitudes and, thus, faster ground speeds, which, in effect, reduce operating costs per mile to a level lower than they would be without pressurization. In the case of short-haul airplanes that do not have the occasion to climb to the more favorable altitudes, pressurization will actually increase the cost of operation. There are intangible benefits, of course, in that we can expect a higher level of passenger comfort and a wider acceptance among the traveling public. Nevertheless, a cost of 2 cents per mile is significant in that it represents approximately 8 per cent of the total maintenance and overhaul cost of a Constellation airplane. This figure is far too high and must be reduced by improved designs and greater reliability between overhauls. To emphasize the importance of designing failure-proof openings, such as windows, we should like to point out that, for each Constellation we are operating, we are spending $3,000 over a 5-year period in replacing windows. These windows are replaced for reasons of safety. You can visualize even tighter inspections for aircraft operating at higher altitudes, and thus our cost of window replacement will be further increased unless window designs and materials are improved substantially.

In summary and in answer to the question "what have we accomplished to date?" I regret to report that much remains to be done. For one, we do not yet have a cabin altitude level that is commensurate with the most desired comfort standards. Also, the automatic control systems do not assure close monitoring of pressure fluctuations, and, again, there remains much need for improving the level of comfort. Cabin compressors and their control systems have not yet reached the degree of reliability desired, and great strides can be made from the standpoint of reducing cost. Windows and doors are not yet 100 per cent reliable; the air-line industry has had cases of window failures, as well as door blowouts.

Now, let us take a look to the future and attempt to consolidate some of our past experience into a requirement for the transport of the future. Our past problems will be magnified by the requirement for greater operating altitudes, and thus it is of utmost importance to solve some of our considerable problems of the past.

Consequently, development of future high-altitude and high-speed transports is believed to offer a challenge to industry with respect to pressurization and associated equipment and structure. First, and most of all,

the structural integrity of the aircraft must be assured completely because of the low survival time that would exist in the event of a blowout at the higher altitudes. It is believed that all apertures (for example, doors and emergency exits) should have retention characteristics equivalent to the inward-opening wedge-fit door. If retention of doors, etc., is to be dependent upon latches and paws, then it is recommended that more than a minimum number of latches and paws be provided and that the design be such that several of the latches, certainly at least any two, can fail without a progressive failure of the door or adjoining aircraft structure. Further, it is my recommendation that windows be designed so that failure of either the window or its supporting structure will not cause a loss of pressurization. If this premise is accepted, then, of necessity, the design must include duplicate windows and attachments, each capable of carrying the full design pressure load. While this approach will add weight to the aircraft, it is, nevertheless, believed necessary. In this connection, two of the newer, presently undelivered, medium-altitude American transports will have independent double windows, each capable of withstanding maximum pressure loads.

Moreover, with turbine power plants installed in the advanced aircraft, it becomes even more imperative, from range and flight-planning points of view, to be assured that the aircraft will not be forced to descend from optimum altitude because of loss of pressurization. While loss of an engine could cause this, it is believed that installed power in aircraft of this type will be such that loss of one engine will not in itself significantly reduce either operating altitude or maximum allowable range; therefore, engine failure will not force the aircraft to lower altitudes.

Even though structural integrity must be assured, I am also sure that auxiliary protection for crew and passengers in event of explosive decompression must be provided. Consequently, and hoping I will not be considered a visionary, I suggest the need for the development of some device that will make use of the passenger oxygen mask unnecessary in case of *sudden* loss of pressurization. While the mask seems to be the only available solution to date, the short interval of time during which the mask must be placed in use after explosive decompression occurs at the higher altitudes compared to the period of time allowable at today's flight altitudes is not reassuring with respect to the practical ability to place a mask in effective use soon enough. Of course, operating altitudes above 20,000 ft. will probably remain an operator's elective and may be arbitrarily limited initially, depending on the degree of conservatism with which we approach a new operation of this type.

From a control standpoint, and even though we have found it advisable in two instances to install manual pressure controls, it is believed, nevertheless, that reliable automatic systems for the control of cabin altitude must be developed from both the operating and passenger points of view. This will permit crew attention elsewhere, particularly during instrument approaches and other periods of intense flight-crew activity. In addition, it is desirable to provide a manual system to avoid flight delays at through stations in event the automatic system does not function properly. It is hoped, however, that such automatic and manual override devices will be simple, reliable, and economical to maintain. It would be helpful toward improved public response if future pressure control devices lessened considerably pressure fluctuations. While much improvement has been made in this phase the past few years, room for improvement still exists. Such improvements should be realized not only at the higher pressure differentials but at the lower differentials as well.

Turning to the compressors, it is undoubtedly tempting for engineers to bleed air from turbine engines for heat and pressurization, but use of a power source independent of engine operation is probably worth considerable investigation, particularly if a system could be evolved to provide adequate hot or cold ventilating air on the ground without the engines running, thus avoiding the cost and bother of ground air-conditioning trucks.

Also dealing with compressors, the presently existing conditions that require either limiting compressor output under certain operating conditions or going to the expense of modifying engine drive pads to accommodate compressor torque requirements are intolerable; the airframe, engine, and pressurization equipment manufacturers must coordinate their requirements and design accordingly for future aircraft.

Sealing of the aircraft against leakage at doors and other apertures will require a greater degree of perfection in high-altitude aircraft than is necessary in today's aircraft because of the effect of leakage on aircraft performance and heating and ventilating. Sealing has at times presented chronic maintenance problems and should, wherever possible, be improved to avoid generating disconcerting air escaping noises and loss in efficiency of the pressurization and heating and ventilating system. On a number of aircraft, after only a few years of service, considerable air is pumped overboard through structural seams in which the original sealant has lost its effectiveness. If leakage aggregates more than the acceptable leakage rate as determined by the reasonable ability to maintain required cabin differential, then the aircraft must be resealed to bring it back to limits. Such resealing would be particularly difficult and would be extremely expensive even if done during periods of major overhaul. While sealants and pertaining methods of installing have undergone improvement, it is hoped that efforts to increase still further the life expectancy of such sealants will continue.

Obviously, the difficult nature of certain developments does not lessen the need for their realization but merely amplifies the challenging nature of the required improvement. Need still exists, not only in super-

(*Continued on page 32*)

Variation in Airplane Range with Wind Velocity

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SUMMARY

A nondimensional procedure for expressing range and cruise speed in terms of average airplane weights leads to simple graphic relationships of the effect of wind velocity on airplane range performance.

From these relationships, increase and decrease in range with a tail wind and head wind, respectively, can be determined easily for any practical ratio of the wind velocity to the optimum cruise air speed for zero wind. The decrease in radius can be determined, also, for any given wind velocity encountered on the outbound and return leg.

The results are presented in simple graphic form and are considered accurate for all practical performance computations.

(1) Graphical Presentation of Range and Endurance

Fundamentally, for any airplane-engine combination the endurance in hours, E, is computed by dividing the total available pounds of fuel, F, by the average pounds per hour consumed by the engine.

$$E = F/\text{lbs. per hour} \tag{1}$$

Similarly, range in miles, R, is computed by multiplying the total pounds of fuel by the average miles traveled per pound of fuel consumed.

$$R = F(\text{miles per lb.}) \tag{2}$$

For an airplane powered by a reciprocating engine, R and E can be graphically represented, Fig. 1, in terms of the airplane power-required characteristics for an average weight condition of the airplane. Propulsive efficiency, η, and engine specific fuel consumption in pounds per shaft or brake horsepower-hour, c, can be considered constant for best cruise speeds and corresponding powers delivered by the engine. By assuming a constant c and η, the ordinate in Fig. 1 is proportional to pounds per hour, since,

$$P_R/\eta = \text{b.hp.}_R \tag{3}$$

$$c(\text{b.hp.}_R) = \text{lbs. per hour} \tag{4}$$

where

P_R = thrust horsepower required
b.hp.$_R$ = brake horsepower required

and the curve of pounds per hour would have the same shape as the P_R curve but displaced vertically by a constant percentage. The speed, V, for maximum E corresponds to the point on the curve for minimum pounds per hour. For maximum R a tangent to the curve through the origin locates the V for maximum R, since this point on the curve has the lowest ratio of pounds per hour/V or the highest ratio of miles per pound.

$$\frac{V}{\text{lbs. per hour}} = \frac{\text{m.p.h.}}{\text{lbs. per hour}} = \frac{\text{miles}}{\text{lbs.}} \tag{5}$$

This is also the speed for maximum airplane lift to drag ratio, $V_{L/D max.}$ In Fig. 1 the ordinate is proportional to $C_D/C_L^{3/2}$, and the abscissa is proportional to $1/C_L^{1/2}$. Therefore, V for maximum range is identical to $V_{L/D max.}$, since the tangent through the origin of the P_R curve also defines the minimum ratio of $C_D/C_L^{3/2}$ divided by $1/C_L^{1/2}$, which is $L/D_{max.}$. With a tail wind or head wind, the V for maximum range is determined by locating the new origins on the abscissa corresponding to the new ground speeds and drawing tangents to the same curve. For both of these maximum-range conditions, of course, the airplane flies at some other air speed than that for maximum L/D. Maximum endurance is a function only of minimum pounds per hour and is therefore unchanged by the tail wind or head wind.

For an airplane powered by a turbojet engine, the rate at which fuel is burned is proportional to thrust output, and the specific fuel consumption in pounds per hour per pound of thrust, c', is approximately constant at best cruise speeds for maximum range. In other words, fuel consumption in pounds per thrust horsepower per hour varies inversely with speed. The speed for maximum range for a given airplane and altitude, then, is a compromise between the speed for best air frame efficiency, $V_{(L/D)max.}$, and the maximum level-flight speed of the airplane provided a parabolic airplane polar is assumed. This relationship is presented graphically in Fig. 2. By assuming a constant c', the ordinate in Fig. 2 is proportional to pounds per hour and C_D/C_L.

$$c'T_R = \text{lbs. per hour} \tag{6}$$

and

$$D = T_R = \frac{W}{L/D} = \frac{W}{C_L/C_D} \tag{7}$$

For a minimum ratio of pounds per hour/V or maximum miles per pound, a tangent to the thrust required, T_R, curve through the origin locates the $V_{max.\ R}$. In terms of airplane characteristics, the point is also

$$V_{(C_L^{1/2}/C_D)max.} \tag{8}$$

since minimum $(C_D/C_L)/(1/C_L^{1/2})$ = maximum $C_L^{1/2} \div C_D$. The speed for maximum endurance corresponds

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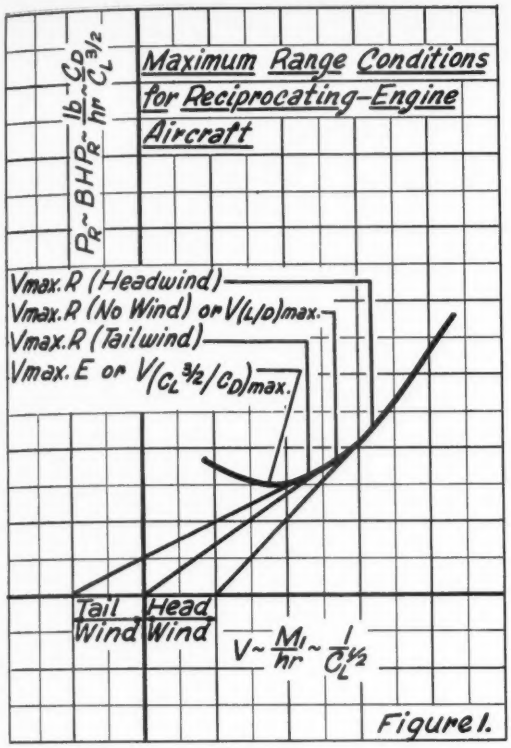
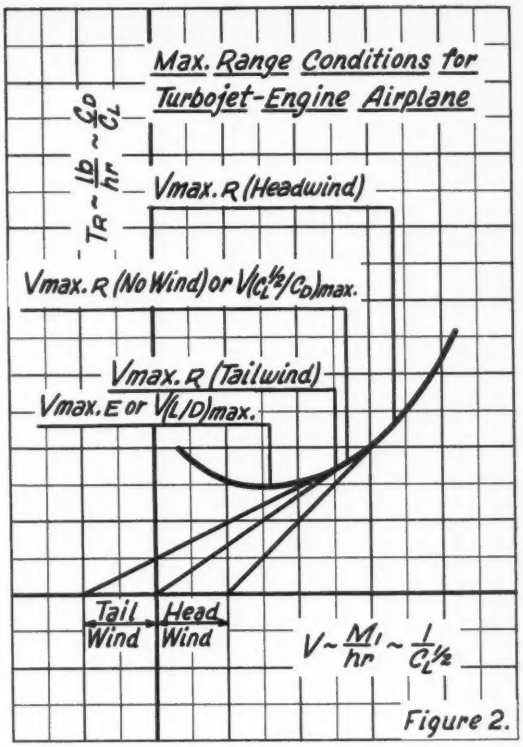




to the speed for minimum thrust required or $V_{(L/D)max.}$. With a tail wind or a head wind, the V for maximum range is determined in the same manner as in Fig. 1.

(2) Effect of Wind on Range of Reciprocating-Engine Airplane[1]

In order to calculate the effect of wind velocity on the range or radius of a reciprocating-engine airplane, the airplane power-required curve is made nondimensional in terms of the parameters plotted in Fig. 3. In general, an airplane thrust-required curve can be written as the sum of the parasite and effective induced thrusts

$$T = AV^2 + (B/V^2) \tag{9}$$

where V is airplane air speed in m.p.h. and A and B are constants that depend on altitude and airplane characteristics.

$$A = \frac{\sigma f}{391}; \qquad B = \frac{124.5}{\sigma e}\left(\frac{W}{b}\right)^2 \tag{10}$$

where

- σ = density ratio
- f = airplane equivalent parasite area, sq. ft.
- e = airplane efficiency factor
- W = airplane weight, lbs.
- b = airplane span, ft.

By analyzing the nature of the two terms in Eq. (9), it is noticed that at one and only one speed are the parasite and effective induced thrusts equal. This occurs at the speed for minimum drag or thrust required or $V_{(L/D)max.}$. To nondimensionalize Eq. (9), it is divided by one-half $T_{(L/D)max.}$, which is common to both the parasite and induced terms only at $V_{(L/D)max.}$. The following form results:

$$\frac{T}{(1/2)T_{(L/D)max.}} = \left(\frac{V}{V_{(L/D)max.}}\right)^2 + \frac{1}{[V/V_{(L/D)max.}]^2} \tag{11}$$

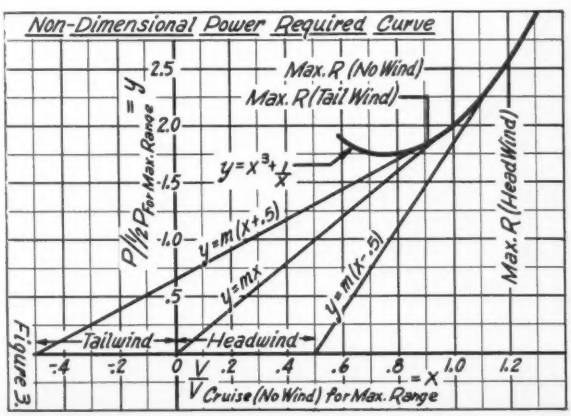
which also can be written as

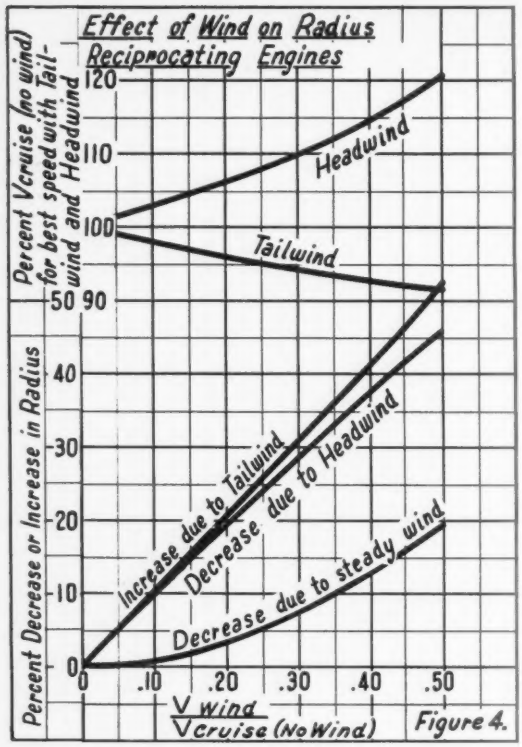
$$y = x^2 + (1/x^2) \tag{12}$$

Since power required is equal to thrust or drag multiplied by speed

$$\frac{P}{(1/2)P_{(L/D)max.}} = \left(\frac{V}{V_{(L/D)max.}}\right)^3 + \frac{1}{[V/V_{(L/D)max.}]} \tag{13}$$

or





$$y = x^3 + (1/x) \tag{14}$$

as indicated in Fig. 3. The cruising air speed for maximum range with no wind is the same as $V_{(L/D)max.}$

The equation of a tangent to the power-required curve in Fig. 3 from any point on the x scale determines the optimum value of x or air speed for maximum range for a given wind condition. As shown in Fig. 4, the per cent of the zero-wind optimum cruise speed to give maximum range can be plotted for head-wind and tail-wind conditions in terms of the ratio of the wind velocity to the optimum cruise air speed for zero wind. The corresponding increase or decrease in range is plotted in Fig. 4 against the same ratio. If the airplane operates over a given radius with and against the same wind, a loss in radius as compared to the zero-wind condition occurs. This decrease in radius for a steady wind condition is also plotted in Fig. 4.

As an example, consider the head-wind ratio condition $V_{wind}/V_{cruise} = 0.5$. From Fig. 3, the equation of a straight line tangent to the nondimensional power-required curve is expressed as

$$y = m(x - 0.5)$$

where m is the slope that is inversely proportional to miles per pound of fuel or range capability. The slope of the power-required curve at the point of tangency is represented by

$$\frac{dy}{dx}\left(x^3 + \frac{1}{x}\right) = 3x^2 - \frac{1}{x^2} = m$$

Then

$$3x^2 - \frac{1}{x^2} = \frac{y}{x - 0.5} = \frac{x^3 + (1/x)}{x - 0.5}$$

$$x^5 - 0.75\,x^4 - x + 0.25 = 0$$

$$x = 1.204$$

which is a cruise V for this head wind 1.204 times the cruise V for the zero-wind condition. For the corresponding ground speed

$$x = 1.204 - 0.5 = 0.704$$

Substituting in the equation

$$y = x^3 + (1/x); \qquad y = 2.579$$

The range capability or the inverse of the slope of the line is then

$$(1.204 - 0.5)/2.579 = 0.2732$$

For zero wind

$$x/y = 0.5$$

and the per cent decrease in range or radius over the zero-wind condition is

$$(100)(0.5 - 0.2732)/0.5 = 45.4$$

In a similar manner, the range capability for a tail-wind ratio of $V_{wind}/V_{cruise} = 0.5$ is inversely proportional to the slope of the line

$$y = m(x + 0.5)$$

and is equal to 0.7615. The per cent increase in radius as compared to the zero-wind condition is then

$$(100)(0.7615 - 0.5)/0.5 = 52.3$$

To determine the decrease in radius for a steady wind of this magnitude, consider a fuel weight in pounds of unity. For a zero-wind condition, the miles per pound of fuel are represented by

$$x/y = 1/2 = 0.5$$

Range is then proportional to 0.5 times 1 = 0.5. Radius is proportional to 0.25. If $\bar{a}$ represents the fuel used with the tail wind, then, against the same magnitude wind, the fuel used is $1 - \bar{a}$. Then

$$0.7615\,\bar{a} - 0.2732\,(1 - \bar{a}) = 0$$

where each term represents the radius for the wind condition. Solving for $\bar{a}$, $\bar{a} = 0.264$ and $1 - \bar{a} = 0.736$. Radius is then equal to

$$(0.7615)(0.264) = 0.2010 = (0.2732)(0.736)$$

The per cent decrease in radius is then

$$(100)(0.25 - 0.201)/0.25 = 19.6$$

as indicated in Fig. 4.

(3) Effect of Wind on Range of Turbojet Airplane

In order to calculate the effect of wind velocity on the range or radius of a turbojet airplane, reference is made to Fig. 2 and the nondimensional thrust-required curve in Fig. 5. The calculation of results is made in exactly the same manner as outlined for the reciprocating-engine airplane. Results are plotted in Fig. 6. As an example, consider the same head-wind condition of $x = 0.5$ or

$$\frac{V_{\text{wind}}}{V_{\text{cruise (no wind)}}} = \frac{0.5}{1.31} = 0.38$$

It should be noted that the best cruise speed for zero wind is 1.31 times that for a reciprocating-engine airplane. From Fig. 5 the equation of a straight line tangent to the nondimensional thrust-required curve is expressed as

$$y = m(x - 0.5)$$

In this case, also, the best cruise speed for this condition is considerably higher than that for a reciprocating-engine airplane. To determine this speed, the derivative of the nondimensional thrust-required curve is equated to the slope of the tangent line.

$$\frac{dy}{dx}\left(x^2 + \frac{1}{x^2}\right) = m = \frac{y}{x - 0.5} = \frac{x^2 + (1/x^2)}{x - 0.5}$$

$$x^5 - x^4 - 3x + 1 = 0$$

$$x = 1.59$$

or $1.59/1.31 = 1.214$ times the cruise speed for the zero-wind condition and

$$y = 2.925$$

The range capability or the inverse slope of the line is then

$$(1.59 - 0.5)/2.925 = 0.373$$

For zero wind

$$x/y = 1.31/2.302 = 0.569$$

and the per cent decrease in range or radius over the zero-wind condition is

$$(100)(0.569 - 0.373)/0.569 = 34.4$$

In a similar manner, the range capability for a tail-wind ratio of

$$\frac{V_{\text{wind}}}{V_{\text{cruise (no wind)}}} = 0.38$$

is equal to 0.796 and the per cent increase in radius as compared to the zero-wind condition is then

$$(100)(0.796 - 0.569)/0.569 = 39.9$$

The per cent of the zero-wind cruise speed for the maximum range with this tail wind is calculated to be

$$1.203/1.31 = 0.918$$

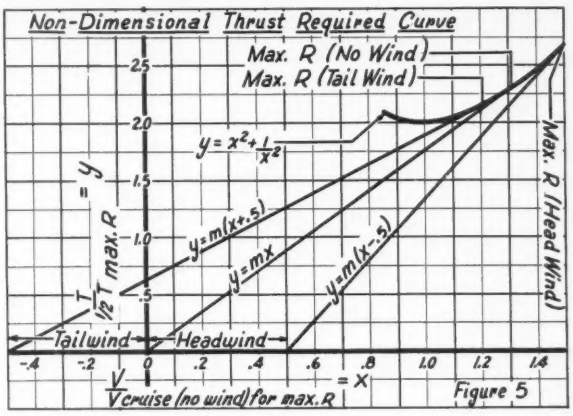


Figure 5

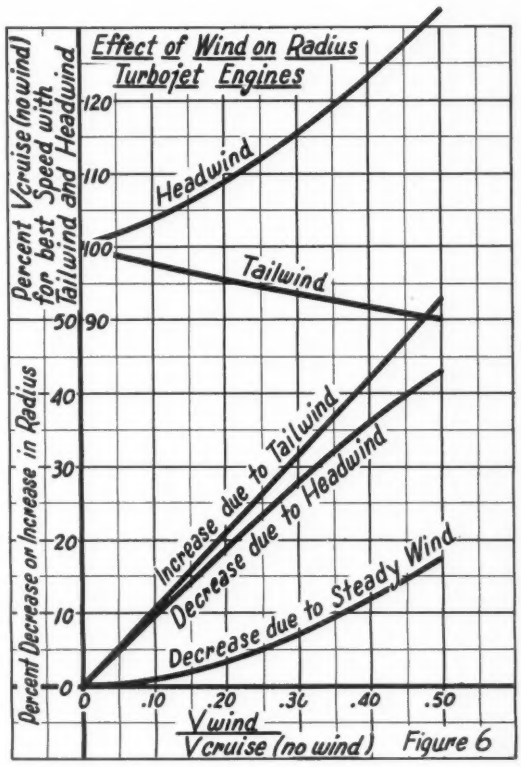


Figure 6

To determine the decrease in radius for a steady wind of this magnitude (tail wind and head wind), the same procedure is used as that in the preceding example for a reciprocating-engine airplane. For a zero-wind condition the range is proportional to

$$x/y = 1.31/2.3 = 0.569$$

and the radius to 0.2845. Assuming that the fuel used with the wind is $\bar{a}$ and the fuel used against the same magnitude wind is $1 - \bar{a}$, then

$$0.796\,\bar{a} - 0.373(1 - \bar{a}) = 0$$

$\bar{a} = 0.319$ and $1 - \bar{a} = 0.681$. Radius is then equal to

$$(0.796)(0.319) = 0.2536 = (0.373)(0.681)$$

The per cent decrease in radius is

$$(100)(0.2845 - 0.2536)/0.2845 = 10.9$$

as indicated in Fig. 6 for a $V_{wind}/V_{cruise} = 0.38$.

The results plotted in Fig. 4 are indicative of an airplane that is powered by an engine that produces approximately constant power and consumes a constant quantity of fuel per unit time at or near the cruise speed for maximum airplane range. The reciprocating engine is a typical example. The results plotted in Fig. 6 are indicative of an airplane that is powered by an engine that produces approximately constant thrust and consumes a constant quantity of fuel per unit time at or near the cruise speed for maximum airplane range. The turbojet engine is a typical example. For an airplane powered by a turboprop engine, the effect of wind on radius or range is approximately halfway between the results plotted in Figs. 4 and 6 for the same values of $V_{wind}/V_{cruise\ (no\ wind)}$.

(4) Limitations of Simplified Procedure

The procedure followed for expressing range in terms of an average airplane weight leads to generalized relationships in simple form. In Figs. 4 and 6 the average speed for maximum range for zero wind corresponds to an average airplane weight that is higher than the target weight. If the fuel to gross weight ratio were extremely high, some error is made in the decrease in radius by assuming an average weight, depending on whether a head wind or tail wind were encountered on the outbound leg and vice versa.

The procedure used also assumes a parabolic drag polar and no increase in drag due to compressibility for best cruise speeds. For turbojet airplanes flying near maximum engine thrust some compressibility error results.

In general, the results presented are within allowable errors for practical computations of the effect of wind velocity on airplane range and best cruise speeds.

Reference

[1] Perkins, Courtland D., and Hage, Robert E., *Airplane Performance, Stability and Control*, pp. 168–171; John Wiley & Sons, Inc., New York, 1949.

Technical Progress and Air Power in the World Crisis

(*Continued from page 13*)

war, in spite of the system and not because of it' . . . Undoubtedly, the country's total technical effort was seriously reduced because of top policy decisions of dubious wisdom concerning drafting of science students and by the arbitrary attitudes and shortsighted actions of the Selective Service headquarters and of draft boards in general. Some commentators and politicians are protesting the so-called "undemocratic favoritism" of keeping technical men at their work on technical matters for our current effort, and the plans for educational deferments receive criticism in certain quarters. Nevertheless, it is mandatory that this draft-exemption problem be handled in the future so that invention and development shall not be starved by lack of thinkers and research workers, and so that the serious shortage of scientists which was created during World War II will not be aggravated. It is gratifying to observe that the present policies of Selective Service seem to favor this. Education in science should be a matter of high priority in Government policy.

"Aeronautical research in universities and institutes of technology has produced excellent results and should be continued at an undiminished rate. Care must be taken to preserve the national asset that we now have in the trained research personnel in these institutions among the faculty, the laboratory staffs, and the students. Far-sighted and enlightened Selective Service administration is needed here, too. Let us not forget that while we were stripping our colleges of scientists and science students during the last war, other nations (notably Russia) were actually increasing their training programs for scientists.

"The present world crisis is different from the situations that preceded World Wars I and II. The policies and actions of our Government this time and the general attitude of the American public are much more realistic and tough-minded than before. We seem, at last, to have decided to build up our strength as a war preventive. Recent events indicate that this policy and our efforts to implement it may be meeting with some measure of success, at least temporarily. If we hope to achieve enduring success in preventing war by being ready for it, we must demonstrate to the world that our purpose does not grow strong or feeble as the world crisis tightens or slackens month by month. A positive and permanent foundation for technical progress in aviation will be one potent and convincing part of such a demonstration.

"The I.A.S. membership, staff, council, and officers, representing the aeronautical engineering and scientific profession of this country, are ready and eager to do their part toward achieving the technical superiority in aviation which the United States must establish and maintain."

Some Special Aspects of Air Transport Safety

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United Air Lines, Inc.

Introduction

THE AVIATION INDUSTRY has learned that accidents in scheduled transportation can be eliminated. This is not idle speculation. It is adequately supported by trends presently existing within the framework of scheduled air transportation. The most singularly effective rule to be followed in accomplishing the no-accident goal is to eliminate the exposure to the accident before it happens.

Several years ago during an accident investigation, a top leader of the industry asked, when several individuals were sharpshooting the principles of the investigation: "Where were all the 'experts' before this accident happened?" This question exposed a serious problem that has long been a stumbling block in the progress toward fundamental safety. If we can "expert" the cause of an accident, then it is not beyond our capacity or intelligence to "expert" the cause before it happens and thereby prevent it. The technique of determining accident causes is well established. If we are willing, we can apply the same initiative and technique to discovery of the exposure.

Perhaps we are young; perhaps we are too enthusiastic and busy with material progress; perhaps we are in a hurry to prove our destiny in the field of transportation. Whatever the cause may be, today there can be no excuse or ignorance of the safety problem. We know too much about it.

In applying the rule of the elimination of exposure, it is necessary for us to study the business of flying an airplane from every angle and to recognize the fact that we are dealing with ordinary human beings and man-made machines. It is important that we realize the limitations of both.

It is not the purpose of this paper to deal with the human element but rather to outline the problems associated with the introduction of new equipment into air-line transportation, which has been, and still is, one of our greatest exposures. Although it is impossible to separate the two completely, the emphasis will be on the technical aspects of the problem.

Presented at the Flight Safety Session, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* Flight Safety Engineer.

Discussion

The transport airplane is the tool with which the air-line operator must work, and for that reason it must be designed for the job. This does not mean that many characteristics of military equipment cannot be successfully utilized, but it does mean that the emphasis must be placed on safety and not on performance.

Performance is important and necessary to the economic success of the air lines. But air-line performance must carry the cushions necessary for day-and-night, all-weather, dependable schedule flying with absolute safety. Throughout the years, the industry, through the Government agencies, has devised what is known as T category requirements. It is believed that the intent of the requirements was to establish minimums of performance and not demonstrated maximums; however, this belief is not shared by all concerned. The case history of a few recent T category airplanes is adequate testimony to the fact that realized performance necessitated the development of new items of accessory equipment, such as automatic feathering and reversible propeller, to enable these airplanes to meet what should rightfully be minimum requirements.

It is true that modern transport design is superior in performance to that of older airplanes. It would be a sad state of affairs if it were not. But, too often, we have used the maximum demonstrated performance as maximum operating performance, assuming that line equipment could and would maintain demonstrated or certificated levels. It is probably desirable to certify aircraft to maximum performance in order to establish a sound base line. This base line should not, however, establish the maximum for line operation when the airplane is introduced. The reason is obvious when we consider the fact that certified performance is based on a standard day atmosphere, which is all well and good; it should be. But the line operating performance is a

function of the density altitude and humidity existing at a given airport at a given time. These factors can be calculated out, but Civil Air Regulations do not completely compensate for them. Consequently, the conservative operation is forced into adequate gross weight cushions to be on the safe side.

Each new airplane designed and built for air-line operation incorporates certain basic advancements over previous equipment. The degree of change, in a large measure, reflects itself all through the early history of adaptation to line operation. Where the technical advance is great, the installation of new and strange devices is more or less a foregone conclusion. The accessory requirements frequently advance with the technical requirements of the basic airplane and in themselves create a problem that enters the field of research and development.

It is here that the manufacturer must discriminate between experimentation and practical application. Too often, we find the specifications coupled with experimental devices that in themselves represent as much of a safety problem as the airplane. The aim of the customer and manufacturer should be to provide a safe basic airplane without resorting to new "on-the-spur" developments to get out of the hole of a "missed approach" to the problem.

Spectacular advancement in design is an attractive goal for an airplane manufacturer. The line operator is sure, however, that such an airplane will provide just as spectacular operating problems and adjustments. It is more or less accidental that they may not be fatal.

A great deal can be done by the manufacturer in the course of test and analysis of a design in the preliminary stages to preclude certain problems that can creep into a completed airplane. It is here that many of the problems that we try to overcome in line operation during the early stages of adaptation are created. The early breakdown of systems and planning with respect to the whole airplane should entail a detailed study of system relationship and operation to preclude the possibility of building accidents into the prototype, which often ultimately results in carrying them into the production models if there is any pressure to move the airplane to meet a deadline.

Deadline delivery dates may seem rather remote from safety. Actually, they have a severe bearing on fundamental safety. The air-line airplane up to this point has been a more or less custom-built job. Its delivery is dependent on traffic estimate and demands, as well as on the economic considerations of delivery. In some cases, the complete results of test and analysis of the prototype have been far from complete by the time the production models start off the line. The net result is that airplanes are delivered with known deficiencies, or they are subject to continuous modification in order to eliminate faults while in actual line operation. To overcome this, both the operator and manufacturer must get ahead of line-equipment delivery far enough to ensure complete development, line testing, and analysis of the prototype before final assembly begins on line models to be delivered to the customer.

The most important and most often neglected phase of prototype testing is the study of simultaneous malfunction of systems and the total effect of such malfunction on the airworthiness of the airplane. It is one thing to anticipate single or multiple failures of a system but another thing to be sure that such failures do not create similar or other chronic failures in another system. A careful study of system malfunction combinations that may create a situation beyond the control of the pilot and crew is required. Such a study is not easy because it is difficult for engineers and pilots to degrade their faith in the man who designs the airplane, just as it is difficult to assume that the one who builds the airplane will make a simple mistake in the process.

Along the same line, the handling qualities and flight requirements must be studied for weak points that could lead the crew into potential trouble. In future precision flight, the lowest possible weather minimums must be anticipated; consequently, the handling qualities of an airplane should lend themselves to such flight requirements. Phrases such as "neutral stability," etc., are good theoretical terms, but they lead to more positive requirements of handling techniques than would otherwise exist. Critical periods are not times to be confronted by treacherous or unpredictable handling qualities.

The same thinking must be applied to operating procedures—both normal and emergency. A procedure is no good with respect to safety if it cannot be completed under stress with accuracy and dispatch. If it takes twelve steps to shut off and feather an engine, then no amount of training research or line testing will ever correct the obvious error made in design. However, we do continue to live with this condition, and any testing must be positive and exhaustive to prove the integrity of all procedures.

Too often, a procedure is used as a crutch for poor design and lack of simplification and, in some cases, to overcome an unsafe condition. Emergency procedures sound like a good thing. Actually, an emergency procedure as such can be a dangerous thing. This is brought about by assuming that a crew can, in an emergency, accomplish a precision procedure of approximately 15 items while flying, navigating, and anticipating further trouble and never miss a beat while doing it. Exposure to this problem cannot be overcome until we realize that an emergency procedure should never be used to overcome a design deficiency. It is only a matter of time until the procedure will not be followed in detail or mechanical failure of an actuator for one phase of the procedure will occur and loss of the airplane be assured.

In consideration of the above, it appears then that no amount of single-purpose testing will actually overcome the basic causes of the safety breakdown of new equipment. The problem is multiphase and requires the best in the way of meeting all of the problems. Consequently, the program must be more detailed and

of earlier origin than an operating test phase. For example, many safety problems are created by weight sacrifices of accessory equipment such as switches, relays, etc. These deficiencies are created by overzealousness on the threshold of aerodynamics and economic performance. The cure is a resignation to the facts of life and grandfather's experience.

Type certification of an airplane actually becomes the effective guarantee to the operator that all C.A.R. requirements are met and certified. If the operator cannot depend on certification as such, then it becomes almost a mandatory requirement for the operator to set up and carry a certification group to double check the original certification.

The operator is largely dependent on the manufacturer, the C.A.A., and C.A.B. for the delivery of equipment that complies to all requirements of certification and airworthiness, and any duplication of those basic activities imposes a severe penalty of time and personnel, as well as dollars. Time and personnel are valuable to us in that any detraction cuts into our normal operating routine and thereby can be a contributing factor to accidents that may not otherwise occur.

Line Testing and Training

The primary delivery of equipment to an air line entails the two fundamental problems of crew training and maintenance training. The degree of advance over previous designs greatly influences the amount and kind of training and the cost. There is no doubt that these two phases have a great deal to do with the ultimate safety of operation of the equipment. Even though the equipment may be sound, we are still confronted with the long periods of familiarity and adaptation required with each new design. The testing period of new design is the period in which instructions, procedures, and techniques must become stabilized so that proper and safe operating techniques can be evolved. We cannot afford the luxury of having inaccurate or incomplete information and instruction material filter into the fundamental training of either flight crews or maintenance personnel.

During the initial periods of line adaptation and testing, it is obvious that the most critical problem is that of familiarizing all operating groups with the airplane and accessories. The cure to most troubles lies not so much in long and continued testing but in the down-to-earth job of getting acquainted. Test runs can never overcome deficiencies in educational training or lack of know-how in everyday maintenance problems. The more advanced the design, the more time it takes. It must be remembered that it took the engineer several years to develop the airplane design, systems, and their interrelation; you cannot expect the air-line engineer, mechanic, or pilot to become totally familiar with it overnight.

The operating time for certain new types of airplanes, running up to several thousand hours, indicates that there should have been sufficient time to detect the causes of subsequent accidents, but there was not. Hence, time *in service* has not proved to be a sound basis of evaluation, nor has a given number of airplanes been a good indicator. Any program must be far more reaching than simple service time on the line. It must be a coordinate program carried out by qualified personnel.

In one recent case, a board of critical experts was given the full authority to investigate and analyze every system of a new airplane, as well as the performance with respect to certification. The results were gratifying in that they provided the operator with a running start on the problems that eventually began to show up. It is expected that, in the future, similar treatment will be given each new airplane and, to a lesser degree, each change of airplane model.

Basic Safety Evaluation

There are a few points that should be remembered with respect to safety evaluation.

(*1*) *There is no substitute for realistic basic design.* The traveling public is not interested in flying in experimental aircraft. The operator is not interested in operating an aircraft that places a high premium on pilot technique or one that will require tender handling. The design must be compatible with all-weather schedule operation and be adaptable to convenient rapid handling and loading on the ground. The designer must understand the operating problem if the design is to be realistic. The operator has the responsibility of stating his problem and presenting his needs, and they should be just as realistic as the manufacturer's design.

(*2*) *The basic safety concept of aircraft design should originate from the safety requirements of operating experience.* The needs in this phase are to establish a conscience in dealing with compromises on the basic safety requirements and to see that they are strictly carried through on the design. From a policy standpoint, it is necessary to argue that no one has yet established basic criteria concerning the question of what is safe. One factor is certain, however—squeezing to meet minimum requirements may well lead to serious problems later.

(*3*) *The degree of advance over previous design should be consistent with other facilities required for line operations and should be within reasonable reach of normal training and familiarization practices.* This means that, when the airplane reaches the line, the operator can be reasonably certain that it can be adapted to line operation without going into drastic new phases of training techniques and that existing facilities are such that the airplane can be operated within adequately safe margins with respect to airport landing aids and traffic-control facilities.

Line Testing and Evaluation

(*1*) *The prototype design and airplane should be subjected to carefully controlled testing to prove the airplane design, the functional systems, and the handling qualities.*

It is true that type certification theoretically covers this phase; however, it is well known that in many cases interpretations of existing Civil Air Regulations have led to serious differences with respect to follow-through. Similarly, there are many ways by which regulations can be met, and, through such means, often the intent of the regulation is effectively by-passed.

(2) *The prototype airplane should then be checked by subjecting it to carefully controlled "malfunctional" tests with respect to individual systems to establish that malfunction of one system does not create equally serious malfunction of another system and to establish the integrity of the basic airplane.* This, plainly speaking, has been a neglected phase of prototype testing. It is essential therefore that such critical combinations be eliminated. All operating procedures required to handle various operating problems must be tried and proved both on the ground and in the air. When the operator receives the airplane, he must be assured that all procedures are complete, accurate, and spelled out in no uncertain terms. Procedures as such should never be a crutch to handle obvious deficiencies of simplification and must be brief and to the point. There should be no surprises in any procedure, especially emergency procedures.

(3) *Line testing or operational testing and proving runs will be the next to final step and, of necessity, the longest step.* This phase covers the following factors:

(A) Aircraft assignment—(a) geographical coverage; (b) seasonal coverage; and (c) meteorological coverage. The purpose of aircraft assignment is to be certain that the type is proved with respect to the direct physical requirements of line adaptation. This can best be done by critical selection of the routes to be flown, with complete subjection to the seasonal and meteorological pattern of those routes. It is important that the airplanes be instrumented for the purposes intended.

(B) Adaptation analysis—The purpose of such an analysis would be to determine the operating limitations of the equipment with regard to flight and maintenance problems. This would include important operations policy decisions such as clearance limitation requirements. Such limitations should include weather limits and equipment dispatch restrictions that may arise from equipment malfunctions, etc.

(4) *Line adaptation should be accomplished through a carefully integrated training program of both flight and maintenance personnel.* The basis of the program would be the derivatives of the first phases. The minimums for training and experience should be determined by the control group. The final step would be familiarizing all operations groups with the basic information of the known airplane. By establishing the minimum requirements, it will be assured that all personnel will start the line operation with an accurate fundamental knowledge of the equipment and its operation limitations.

Finally, the development group should be composed of teams well-qualified for the basic job of evaluation.

(1) *Pilots*—qualified line pilots who have the qualifications of critical analysis and flight testing but who are not necessarily qualified as engineers. In fact, it would probably be better if they were not engineers so as to preserve their basic line flying attitude.

(2) *Engineers*—qualified for the job of critical engineering test work and thoroughly familiar with the instrumentation required for critical analysis in their field.

(3) *Maintenance analysts*—qualified personnel capable of analyzing the en-route maintenance problems for the development of practical solutions to the problems found during the test on proving period.

(4) *Control group*—this group would define and analyze the entire program and be responsible for issuance of the final factual reports covering all phases of the program.

The number of aircraft required would have to be a compromise of economics and the thoroughness of the program, coupled with estimated expectancy of variations in production control.

In consideration of all phases of line evaluation, safety evaluation is probably the most important. We cannot lose sight of the economic aspects in making such an analysis, because after all the safest way to fly is in the hangar. The safety engineer must realize that he is a part of a business. His job is to find ways and means of promoting safety without destroying the business. Experience at the present time indicates that this can be done by doing what we end up doing but doing it a little earlier in the game. Safety is peculiar in that it is not very important until it comes home.

We can eliminate accidents by eliminating the exposure to them, and, to eliminate the exposure in the airplane, safety consciousness must start with it in the beginning and grow up with it. It is not easy, but it can be done.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal and Review*.

Notices should be printed legibly and sent directly to the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y.

A Tested Solution of the Problem of

Helicopter Stability and Automatic Control

DONALD N. MEYERS,* EDWARD G. VANDERLIP,† and P. HALPERT‡

Piasecki Helicopter Corporation and Sperry Gyroscope Company

Introduction

Helicopter development has now reached a stage where the aircraft is performing many important military and commercial operations. The full capabilities afforded by the helicopter have been limited, however, by a definite lack of stability, and the solution of this problem has perplexed the industry since its beginning. This lack of stability has made it difficult and tiring to fly long periods of time and has limited helicopter operations under instrument conditions.

Military and commercial requirements for all-weather flight and reduction of pilot fatigue made it necessary to find a solution to the problem if the helicopter was to be utilized to its full potential. A goal was set that went beyond merely providing stability because it was evident that the full capabilities of the helicopter could not be used until automatic flight was also provided. It was therefore decided that the goal should be the attainment of automatic flight, which in itself would also solve the problem of stability.

The project was sponsored by the Bureau of Aeronautics of the U.S. Navy. The test aircraft used was the Piasecki XHJP-1, built for the Navy as the experimental prototype of the HUP-1 and shown in Fig. 1.

The Automatic Pilot As a Solution

Broadly speaking, stability is recognized as a characteristic inherent in, or imparted to, an object to return it to its initial attitude after it has been disturbed. Control may be defined as the ability to exercise a directing influence. A study of what is desired and expected in the way of stability and control has resulted in the following conclusions:

(1) The control forces and attention required for piloting must be such that long instrument flight can be made without undue pilot fatigue.

(2) When disturbed in hands-off flight, the helicopter must return to a trimmed attitude without undue oscillation.

(3) When the control is returned to neutral after having been moved, the helicopter must return to its original attitude. In other words, each position of the control should produce a corresponding trimmed attitude.

(4) It must be possible for the pilot to divert his attention to other duties for periods of several minutes or more.

(5) The stabilizing action must be effective throughout the entire speed range, including hovering; should be effective in both stick-free and stick-fixed conditions of flight; and must not materially reduce the maneuverability or controllability of the helicopter.

(6) Preferably, the stabilizer should be so designed that it can be used without major modifications to existing single- and multirotor helicopters.

The root of most helicopter stability and control problems lies in the hinged-rotor system. Tilting of the rotor relative to the fuselage, or vice versa, produces a control action that may not be originated by the pilot. This relative movement between the rotor and the swash plate is caused by external disturbances such as gusts and directional changes of airflow. The effect of such an arrangement is to provide these external forces with a powerful control to change the attitude of the helicopter. To offset this, the pilot must be provided with an equally powerful control. This requires a control system that is extremely sensitive, and, unless the pilot is well trained, he may have difficulty in handling the aircraft. Because of the many structural advantages of the hinged-rotor design, however, many in the industry have decided to retain it and to overcome the problems involved in its use in some other manner.

A review of the requirements and of other approaches to the problem pointed to the use of gyrostabilization as

Fig. 1. XHJP-1 helicopter used for automatic pilot evaluation

Presented at the Rotating Wing Session, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* Assistant Chief, Research and Development, Piasecki.

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‡ Department Head, Flight Control Engineering, Sperry.

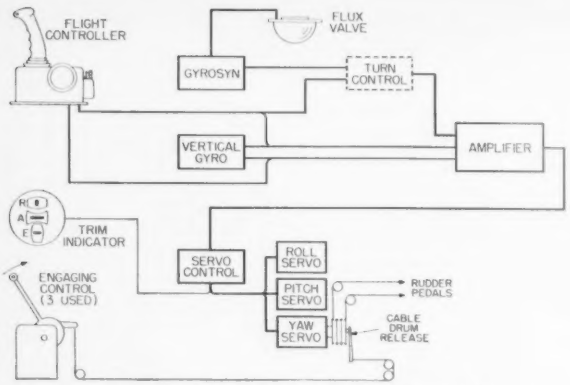

FIG. 2. Block diagram of basic A-12 gyropilot.

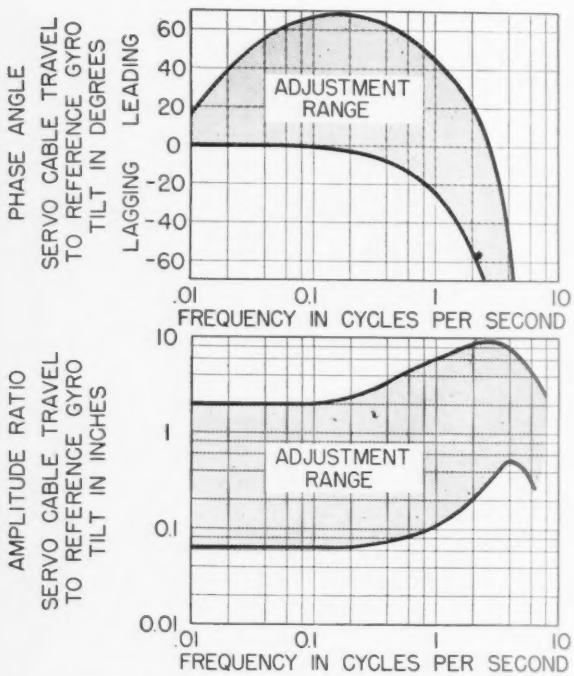

FIG. 3. Range in A-12 gyropilot response characteristics obtained by tap switch adjustments.

the best solution. First, however, it was necessary to analyze the failures of previous attempts to use automatic pilots in helicopters.

In studying actual piloting actions required to handle a helicopter, it appeared that good pilot technique did not depend so much on how much control was applied to correct for a certain disturbance or a change of attitude of the helicopter but rather on how much opposite control was applied to counteract the angular velocity caused by the initial control fed into the system. The study of the control motions showed that the pilot was actually unconsciously measuring the amount of control which he applied for a certain deviation of attitude and would apply a predetermined amount of opposite control that would offset this. In other words, he was measuring the rate of response which his application of control correction caused. It was therefore obvious that what was actually needed in the automatic pilot was some means of measuring this rate of aircraft response, a feature that early automatic pilots did not have. It was equally obvious that the servosystem had to have a fast response. Otherwise, the rate signal would be averaged out and would lose its identity.

The model A-12 gyropilot, produced by the Sperry Gyroscope Company, was chosen as most likely to produce the desired results with the least amount of development. There were five reasons for this choice:

(1) The A-12 is equipped with both displacement and rate circuits on all three axes.

(2) The servos have a high torque-inertia ratio and thus give fast response.

(3) The amplifier has a wide range of adjustments, which could be changed in flight, thus shortening the hours of flight testing.

(4) The A-12 had already successfully stabilized a variety of aircraft ranging from jet fighters to blimps.

(5) The A-12 was immediately available for an accelerated program and needed little modification.

PRINCIPLES OF THE A-12 GYROPILOT

A wide background exists among manufacturers and military agencies in the design and application of automatic control systems to fixed-wing aircraft. The A-12 gyropilot is an automatic control system that is specifically designed for use in turbulent air and for operations necessary in all-weather flight. The characteristics of the gyropilot can be varied over a wide range to give the required performance in different aircraft types. Automatic pilots are now used for routine operations in such aircraft as commercial air liners, heavy bombers, jet fighters, blimps, and drones.

In its application to the helicopter, the gyropilot acts to maintain the craft in a definite attitude and on a prescribed heading for both forward and hovering flight. A system of gyroscopes establishes a set of space axes that then become the attitude and heading references. Electric signals from the gyroscope system indicate departures of the craft from reference. These signals are amplified electrically and are applied to a servomotor. The servo actuates the aircraft's primary controls. A diagram of the gyropilot is shown in Fig. 2.

The action of the automatic control system on the aircraft has an effect comparable to a centering spring in a mechanical system. For example, if the aircraft is acted upon by a disturbance that causes the attitude to depart from the reference, the controls are moved a proportional amount in a direction to restore the craft to its original attitude.

Displacement gyros are used to detect departures of the helicopter's attitude from a preset gravitational reference and magnetic course. The directional reference is furnished by a heading gyro whose spin axis is aligned to the horizontal component of the earth's magnetic field in a manner similar to the gyrosyn compass.

The element sensitive to the earth's magnetic field is remotely located in the aircraft away from any magnetic disturbances. A vertical gyro is used to establish the roll- and pitch-attitude reference. The spin axis of the vertical gyro is normally maintained parallel to the direction of gravity.

Departure of the aircraft from the gyro reference is measured by mounting a synchro unit so that the rotor is fixed to the gyro and the stator is attached to the aircraft. Motion of the aircraft, with respect to the gyro, generates a signal that indicates both direction and magnitude of the error. Initial references are established at the time the system is engaged. This synchronizing action is accomplished by continuously nulling any gyro signal that may exist at the time of engagement.

The servosystem consists of a modified form of Ward-Leonard drive. The amplifier output controls the field excitation of a d.c. generator that in turn energizes the servomotor. Voltage signals measure the displacement of the servo-output member and are fed back to the amplifier, thus creating a closed loop position servosystem. The feedback system is necessary to obtain high dynamic response and also to ensure that the motion of the servo is proportional to the control signal. The servo can be tailored to a particular aircraft control system by gear changes within the servo or by variation in the amount of feedback voltage.

The A-12 gyropilot acts to retain the compass heading prevailing at the time of engagement. To change course, the aircraft is banked, and the heading reference is rotated at the rate desired. The aircraft comes out of the turn stabilized on its new heading. For a particular aircraft, the relationship between bank angle and rate of turn is set to produce a coordinated turn at the cruising air speed. Rate of turn is controlled by the flight controller. In conventional aircraft, a coordinated turn can be achieved throughout a range of air speeds by varying the rate at which the heading reference is rotated in accordance with the average rudder deflection. To make this system applicable to the helicopter, which is required to turn while hovering, modifications were made to permit turns at zero speed.

The use of an automatic pilot in an aircraft for all-weather flight places exacting requirements on the system. These requirements are met by providing "tight" stabilization against outside disturbances. The aircraft is permitted to depart only a few degrees from its reference attitude even in extremely gusty air. Under this condition of tight constraint of the aircraft to the reference, the inherent aerodynamic damping of the aircraft is no longer sufficient to prevent hunting. This is particularly true in the case of the helicopter, which has little inherent damping. The automatic pilot must furnish the additional damping required. To produce this characteristic in the control, signals from the reference gyroscopes are introduced into individual electronic rate networks. The output from these networks is added to proportionate amounts of the corresponding displacement signals. The combined signals are then used to actuate the servosystem. Presence of these rate signals has the effect of synthesizing the required additional aircraft damping.

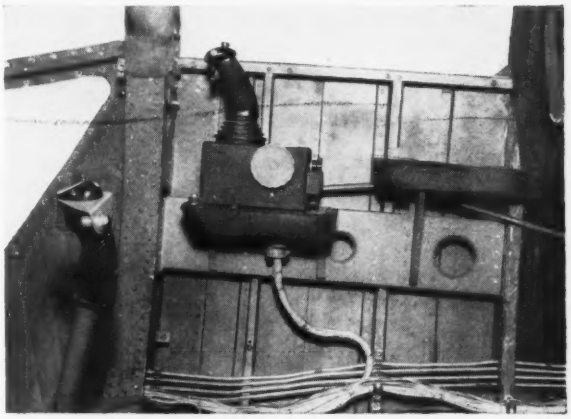

FIG. 4. Flight controller installation.

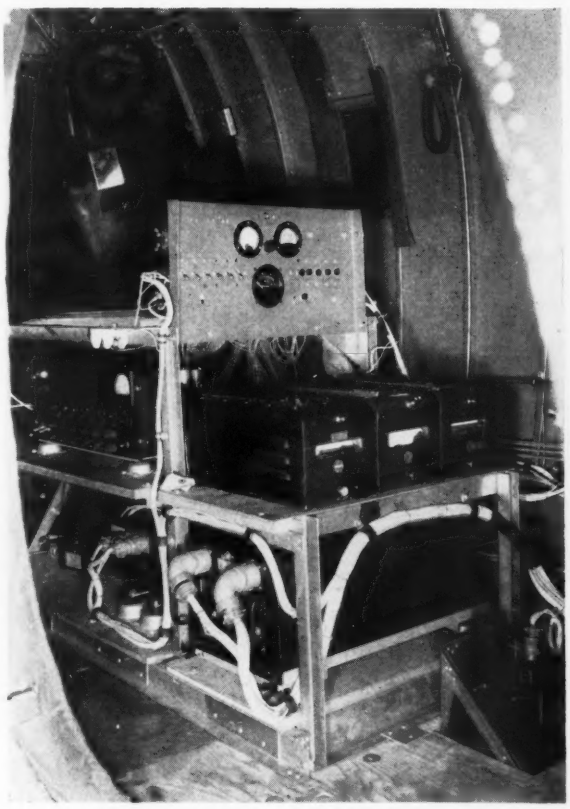

FIG. 5. Installation of gyropilot and flight-test instrumentation.

For use of the A-12 in different types of aircraft, the flight amplifier unit has been equipped with a series of gain-selector tap switches. These switches permit the individual adjustment of aircraft rate, displacement, and servosystem gains. A typical range in system characteristics which can be obtained is shown in Fig. 3.

FIG. 6. XHJP-1 hovering on automatic pilot. Hands of both pilots are visible.

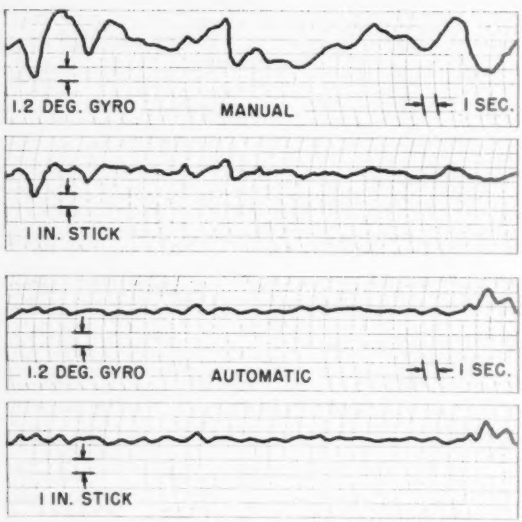

FIG. 7. Comparison of pitch characteristics in forward flight.

INSTALLATION IN XHJP-1

The servos are coupled directly in parallel with the control system in the same way as in a conventional airplane installation. Thus, rotation of the rudder servo causes corresponding motion of the rudder pedals and of the entire rudder control system. In a similar manner, rotation of the pitch servo causes fore and aft motion of the main stick, and rotation of the lateral servo causes lateral motion of the main stick.

When flying the helicopter by means of the gyropilot, the pilot permits the stick and rudder pedals to move freely. All control of flight attitude is maintained by means of a flight controller located to the right of the main stick convenient to the pilot as shown in Fig. 4. The flight controller consists of a hand grip, similar to that on the main stick, mounted on a small box that contains a switch for turning on the electrical system and trimming controls for pitch and roll. A given position of the flight controller in the fore-and-aft direction produces a signal calling for a definite attitude of the helicopter in pitch. Each lateral position of the flight controller produces a signal calling for a definite angle of bank and a corresponding coordinated rate of turn.

An emergency release button is provided to cut out the gyropilot for manual control. The servos may also be mechanically disconnected from the control system by clutches operated by three "engaging control levers" convenient to the pilot. A trim indicator mounted on the console indicates correct functioning of the system.

The amplifiers, gyros, and test instrumentation are all mounted on racks in the main cabin of the helicopter. The installation of these components is shown in Fig. 5. On the upper rack can be seen three Brush recorders and their amplifiers for recording simultaneously the control displacement and aircraft attitude about all three axes as functions of time. Just above them is a panel with switches and circuit breakers for the various circuits and meters to check the d.c. voltage and the a.c. voltage and frequency. On the bottom rack in the foreground is the gyropilot electronic amplifier. Directly behind it is the "servo-control unit" that controls the input voltage to the servomotor armatures. Also on this bottom rack are the vertical gyro and the directional gyro.

A flight observer was stationed within reach of this equipment to make adjustments to the gyropilot amplifier in flight using the Brush recorder data as a guide. This ability to make adjustments in flight was a tremendous help in shortening the testing time.

PERFORMANCE

On the morning of September 16, 1950, the installation of flight and instrumentation equipment had been completed, and the aircraft was ready for testing. In these first flight tests, only the roll and pitch servos were engaged. After one hour and 15 min. of flight time, during which several adjustments were made to the tap settings of the amplifier, stabilized flight in hovering was achieved, and it was possible to maneuver the helicopter about its roll and pitch axes in a satisfactory manner.

On the afternoon of that same day, forward flights up to speeds of 80 knots were made. The performance of the automatic pilot system was good except for a slight longitudinal hunting. After several adjustments in flight, longitudinal hunting was reduced. The aircraft was brought back to the landing mat, and two landings were made using only the automatic pilot controls.

In a total time of two hours and 34 min., stability and automatic control were achieved in hovering and forward flight about the roll and pitch axes of the helicopter. It was possible to fly the helicopter through any maneuver normally performed with the cyclic stick, and these maneuvers were much easier to perform than had ever been possible before. In fact, a service pilot who had never before flown a helicopter, after a short briefing, took off, flew, and landed the ship—all within 20 min. Fig. 6 shows an XHJP-1 hovering in hands-off flight close to the ground.

The next flight tests were made with the rudder axis engaged in combination with the roll and pitch axes. Practically no difficulty was encountered in cruising flight, and, with few adjustments, deadbeat stability was obtained. Well-coordinated turns were easily made through the flight controller. In extremely slow flight and hovering, however, control was unsatisfactory with the rudder servo engaged. The reason for this lies in the operation of the turn-control circuit in the gyropilot, which is not applicable in hovering flight.

The problem was solved by installing a switch with which the rudder servo could be cut out of action. Hovering turns could then be made with ease by controlling the rudder pedal manually, while the helicopter continued to be stabilized in roll and pitch. The rudder servo can be connected again at any time, and the helicopter becomes stabilized on its new heading.

Two G.C.A. runs were made at Willow Grove Naval Air Station, where the pilot was talked into a predetermined position over the runways. Both of these runs were successfully completed, and the pilot commented that it was easy to handle the helicopter on instruments and that its operation under these conditions was not tiring.

The performance of the helicopter under automatic control is measured by simultaneously recording attitude and corresponding control motions. Recording the gyro signal gives the attitude of the helicopter, and control position is obtained from a pick-off attached to the control system. Two types of measurements are made. One compares the deviations in attitude and the corresponding control motions under manual control with those obtained when the helicopter is controlled automatically. The other measures the transient characteristics of the system.

Transients are applied by moving the control stick a small amount and quickly returning it to its original position. This is equivalent to overpowering the servo until the attitude deviation reaches several degrees and then suddenly releasing the servo. The manner in which the helicopter returns to its original attitude indicates the amount of damping in the system.

Comparisons of manual and automatic control for forward flight are shown in Figs. 7, 8, and 9. Similar records for hovering flight are shown in Fig. 10. Transient characteristics are shown for both forward and hovering flight in Figs. 11 and 12.

The effect of the rate circuits is clearly evident in the transient recordings, for, in all cases, the servo returns

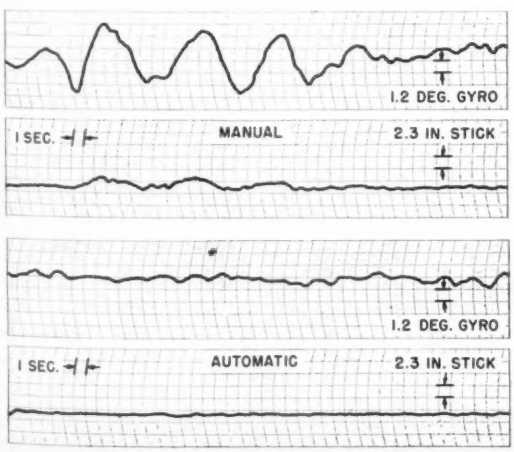

FIG. 8. Comparison of roll characteristics in forward flight.

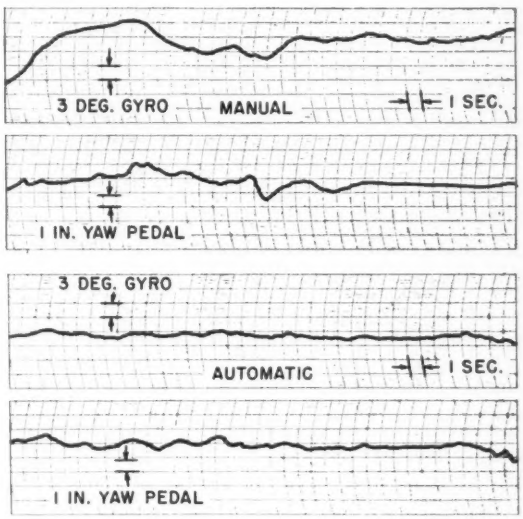

FIG. 9. Comparison of yaw characteristics in forward flight.

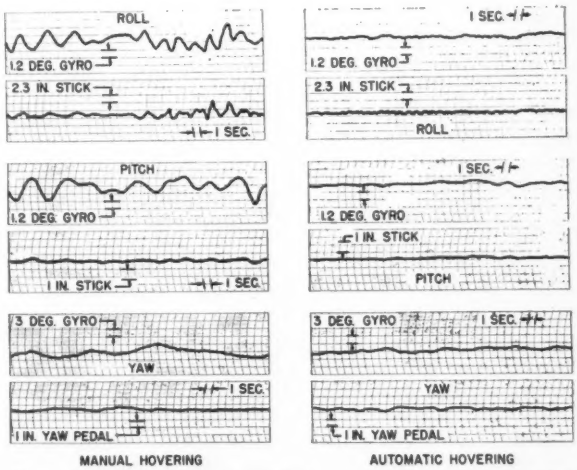

FIG. 10. Comparison of attitude characteristics in hovering flight.

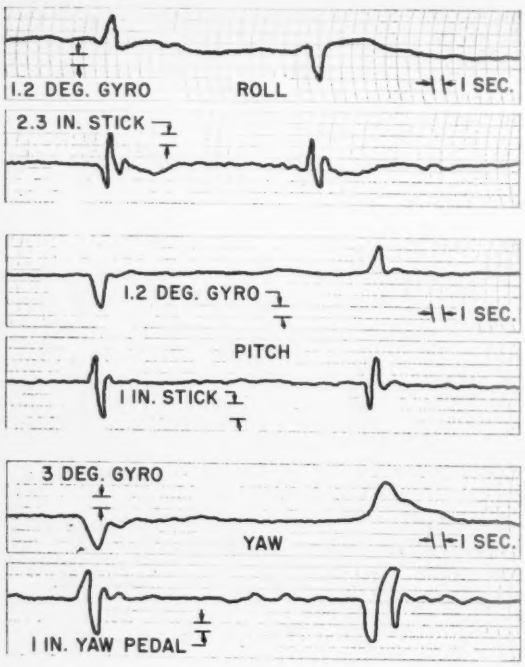

FIG. 11. Attitude transient characteristics in forward flight.

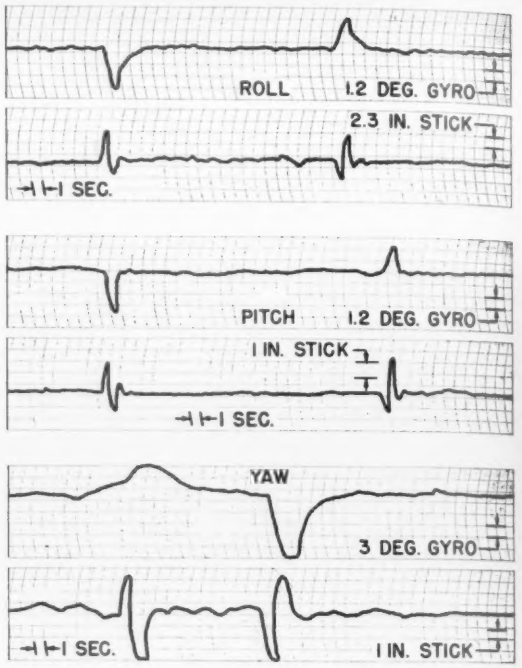

FIG. 12. Attitude transient characteristics in hovering flight.

to neutral ahead of the attitude. In some instances, the servo actually reverses to prevent the helicopter from overshooting.

CONCLUSION

It has been demonstrated that the XHJP-1 helicopter has been successfully stabilized by incorporating the A-12 gyropilot in the control system. It is easy to fly in forward flight, coordinated turns, hovering flight, take-off, and landing. Instrument flight is no more difficult than with a conventional airplane. In fact, instrument landings are easier than with a conventional airplane because the helicopter is inherently capable of slow and hovering flight.

The automatic pilot will permit much wider utilization of the helicopter by allowing flight for long periods of time without pilot fatigue and under all weather conditions. The successful application of the automatic pilot to helicopters, moreover, adds to passenger comfort by maintaining a steadier flight attitude. Another of its major contributions is to permit more precise navigation. The automatic pilot will become an even more basic necessity to helicopter flight when it is utilized in conjunction with radio aids to navigation.

General Aspects of Cabin Pressurization (Continued from page 17)

chargers but in some other devices as well, for determining impending failure, particularly with regard to bearing and other important mechanical failures. Perhaps a reliable signal device triggered with a maximum permissible rate of temperature increase would offer some promise for the avoidance of bearing failures, although the preferred method, naturally, is to build bearings and other working parts that simply do not fail. The latter course is the goal, but, until such time as this appears practical of attainment, improved warning devices seem in order.

The foregoing has been generalized but outlines in essence a few improvements that I consider desirable for aircraft pressurization systems, as well as briefly summarizes some operating experiences. The progress made since the development of the original Stratoliner in 1937 is large, and we are confident progress will continue. While the plea for system simplification is often repeated, nevertheless, general simplifications of design, installation, parts, controls, and operating procedures remain the most fertile fields of improvement in aircraft pressurization systems. Systems have generally grown more complex over the years, basically because of demands for improved and refined system performance, because of the introduction of cooling equipment, and because the operating altitudes of aircraft have been increased, thus broadening the band of aircraft operating environment. Reversal of this trend will not be accomplished unless forcefully and unrelentlessly attacked. The main purpose of pressurization is to provide a pleasing and acceptable comfort standard to the fare-paying passenger and to ensure on-time operating reliability. With this in mind, let us strive to correct our past difficulties and move on to broader aircraft travel acceptance, operating reliability, and reduced operating cost.

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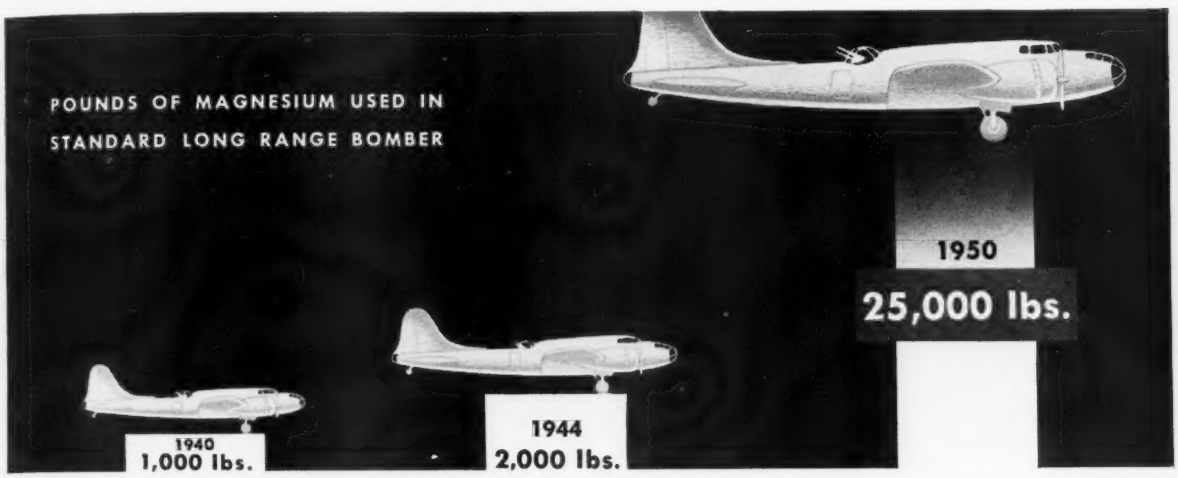

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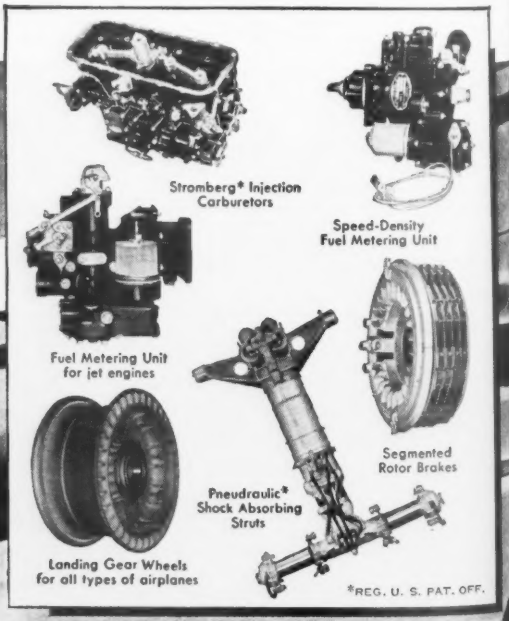
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I.A.S. News (Continued from page 9)

News of Members

▸ **Reginald M. Cleveland** (A.M.), *New York Times*, was elected to the Presidency of the Wings Club.

▸ **Dr. Hugh L. Dryden** (H.F.), Director, N.A.C.A., was appointed on April 20 to membership on the Science Advisory Committee. This group is a part of the Office of Defense Mobilization.

▸ **Fred M. Glass** (A.M.), Director of Airport Development, The Port of New York Authority, was elected a Director of the Airport Operators' Council at the A.O.C. annual meeting in Memphis, Tenn.

▸ **Myron B. Gordon** (A.F.), Management Consultant, Air Associates, Inc., has been elected to the Board of Directors, Air Associates.

▸ **Brigadier General Donald J. Keirn,** U.S.A.F. (A.F.), Headquarters, Air Research and Development Command, Washington, D.C., was recently promoted from the grade of Colonel.

▸ **James H. Kindelberger** (F.), I.A.S. Past-President and Chairman of the Board, North American Aviation, Inc., was decreed a Chevalier de la Legion d'Honneur by the President of France. Presentation of the Legion of Honor was made recently by Gen. Charles F. Lecheres, Chief of Staff, French Air Force.

APPOINTED S.A.E. COMMITTEE CHAIRMAN

B. N. Ashton (A.F.), President, Electrol Incorporated, was named to the Chairmanship of the A-12 Committee, Society of Automotive Engineers. This particular committee reviews and makes comments on military specifications related to shock struts and associated equipment. In addition, it also works on industry problems arising from new developments.

▸ **Jerome Lederer** (F.), Director, Flight Safety Foundation, Inc., was elected Secretary of the Wings Club.

▸ **Luis Alfredo Sepulveda** (M.), Mechanical Research Engineer, Applied Mechanics, Armour Research Foundation, Illinois Institute of Technology, received his Master's degree in Mechanical Engineering last month from Illinois Tech.

▸ **Igor I. Sikorsky** (H.F.), Engineering Manager, Sikorsky Aircraft Division, United Aircraft Corporation, was accorded the American Helicopter Society's top honor—The Dr. Alexander Klemin Award. Mr. Sikorsky is the first recipient of this award, established by Frank N. Piasecki (T.M.), Chairman of the Board, Piasecki Helicopter Corporation. Honoring the memory of the pioneer rotary-wing aircraft engineer, this award is given for "notable achievement in the advancement of rotary-wing aeronautics." It was presented at the A.H.S.'s Seventh Annual Forum held last April in Washington.

HONORED BY ASSOCIATES

Dr. Henry J. E. Reid (F.), Director, Langley Aeronautical Laboratory, N.A.C.A., Langley Air Force Base, Va., was the Guest of Honor at a smorgasbord dinner at his headquarters on April 30. On this occasion, about 200 of Dr. Reid's long-time associates convened from many different points to pay homage to him for his recently completed 30 years of service with the N.A.C.A. Speakers at the festivities included Dr. Hugh L. Dryden (H.F.), Director of the N.A.C.A., and Dr. John F. Victory (M.), N.A.C.A.'s Executive Secretary. Dr. Edward R. Sharp (F.), Director, Lewis Flight Propulsion Laboratory, N.A.C.A., Cleveland, served as Master of Ceremonies.

Members on the Move

This section is for the purpose of giving information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

Enrique Aguilera (M.), now Engineer, McDonnell Aircraft Corporation.

Don O. Benson (M.), Manager, General Aircraft and Communications Engineer, Northwest Airlines, Inc. Formerly, Superintendent, Aircraft Engineering, Northwest Airlines.

Richard L. Bills, Jr. (T.M.), now Unit P.O. No. 1, Box 838, Randolph Air Force Base, Tex.

C. W. Bogart (T.M.), Aeronautical Engineer GS-9, Office of Bureau of Aeronautics Representative, Akron, Ohio. Formerly, Junior Aerodynamics Engineer, The Glenn L. Martin Company.

Dr. B. G. Bromberg (A.F.), Chief Engineer, Guided Missile Engineering Division, McDonnell Aircraft Corporation. Formerly, Head, Missile Department, McDonnell.

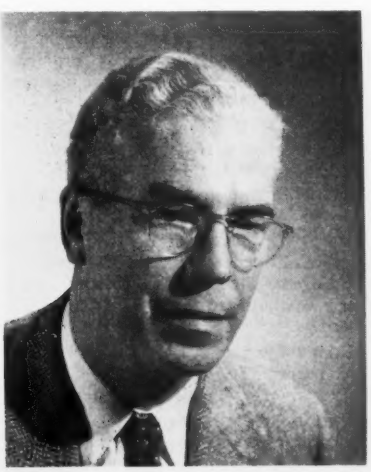
Rene Bussiere (M.), Assistant Project Engineer, Wright Aeronautical Corporation, Curtiss-Wright Corporation. Formerly, Project Engineer, American Power Jet Company.

H. Lloyd Child (A.F.), Assistant Director, Republic Aviation Corporation's Activities, Edwards Air Force Base, Calif. Formerly, Executive Secretary, Non-Scheduled Flying Advisory Committee.

Robert C. Curry (T.M.), Senior Engineer, Structures and Accommodations, Maintenance and Supply Depot, American

NEW BUAER CHIEF

Rear Adm. Thomas Selby Combs, U.S.N., H.M.I.A.S., took over the duties as Chief, Bureau of Aeronautics, Department of the Navy, on May 1 for a 4-year term. Prior to this assignment, he had been Chief of Staff and Aide to Commander in Chief, Atlantic Fleet. He has been with BuAer previously, serving from 1946 to 1948 as its Deputy Chief. Admiral Combs was graduated from the U.S. Naval Academy in 1919 and was designated a Naval Aviator in 1922.



N.A.C.A. HAS NEW MEMBER

Dr. John F. Victory, M.I.A.S., Executive Secretary, N.A.C.A., is shown swearing in Donald W. Nyrop, H.M.I.A.S. (right), Chairman, Civil Aeronautics Board, as a member of the N.A.C.A. Mr. Nyrop succeeds Delos W. Rentzel, H.M.I.A.S., in this position. Swearing-in ceremonies took place in Mr. Nyrop's office on April 26.

Airlines System. Formerly, Engineer, Maintenance and Supply Depot, American.

Mario Di Giovanni (M.), Chief Engineer, Robert Mayer Associates. Formerly, Dean of Engineering, Stewart Technical School.

Robert L. Fischer (T.M.), now Engineer "C," McDonnell Aircraft Corporation.

Carl L. Frederick (M.), President, Frederick Research Corporation, Chevy Chase, Md. Formerly, Consultant, Research and Development Board, Office of the Secretary of Defense, Washington, D.C.

Richard H. Frost (A.F.), Assistant Chief Engineer, Stanley Aviation Corporation. Formerly, Senior Project Engineer, Stanley Aviation.

A. W. Hohensee (M.), Missile Design Engineer, Ordnance Guided Missile Center, Redstone Arsenal, Ala. Formerly, Designer, General Electric Company.

Charles Horne (H.M.), Administrator, Civil Aeronautics Administration. Formerly, Director, Federal Airways, C.A.A.

Ilia I. Islamoff (M.), Assistant Production Manager, Pusey and Jones Corporation. Formerly, Supervisor, Sheet Metal Department, Pusey and Jones.

E. E. Larrabee (T.M.), Assistant Professor, Department of Aeronautical Engineering, Massachusetts Institute of Technology. Formerly, Instructor, Aeronautical Engineering, M.I.T.

James A. Martin (T.M.), Aeronautical Research Intern, High Speed Flight Research Station, Edwards Air Force Base, Calif. Formerly, Engineering Draftsman "B," Structures Group, Douglas Aircraft Company, Inc.

A. Howard Meyers (T.M.), now Machine and Tool Designer, Mechaneers, Inc.

Charles W. Morris (M.), now Vice-President—Engineering, Domanco Company.

Major Edmund E. Novotny (T.M.), Commanding Officer, 131st Field Maintenance Squadron, 131st Fighter-Bomber Wing, Bergstrom Air Force Base, Tex. Formerly, Assistant Flight Test Engineer, McDonnell Aircraft Corporation.

Donald W. Nyrop (H.M.), Chairman, Civil Aeronautics Board. Formerly, Administrator, Civil Aeronautics Administration.

William A. Oconnicof (M.), Commercial Casting (Engineering Consultants), 8855 Santa Monica Blvd., Los Angeles. Formerly, Engineer, Ryan Aeronautical Company.

Frederick C. Phillips (M.), Test Engineer, Helicopter Division, McDonnell Aircraft Corporation. Formerly, Professor of Aircraft Design, Aeronautical Institute of Technology, Brazil.

William H. Renison, Jr. (A.F.), Factory Manager, Hiller Helicopters. Formerly, Industrial Management Engineer, Overhaul and Repair Department, Naval Air Station, Alameda, Calif.

Delos W. Rentzel (H.M.), Under Secretary of Commerce for Transportation, U.S. Department of Commerce. Formerly, Chairman, Civil Aeronautics Board.

Brian Sparks (M.), Vice-President, Avron Corporation. Formerly, Captain, American Overseas Airlines System.

Horton Guyford Stever (M.), Associate Professor, Department of Aeronautical Engineering, Massachusetts Institute of Technology. Formerly, Assistant Professor, Aeronautical Engineering, M.I.T.

John T. Strickland (M.), Senior Group Engineer, Boeing Airplane Company. Formerly, Head, Flight Test Division (N.A.M.T.C., Pt. Mugu, Calif.), Fairchild Guided Missile Division, Fairchild Engine and Airplane Corporation.

Harold W. Thomas (A.F.), Assistant Chief Inspector, Quality Control Division of Fighter Manufacturing, Lockheed Aircraft Corporation. Formerly, Executive Trainee in a course involving extended visits to all organizations within Lockheed Aircraft Corporation.

Henry C. Victorian (T.M.), Stress Analyst, Hiller Helicopters. Formerly, Design Engineer, Cessna Aircraft Company.

Harry H. Wallace (M.), Executive Engineer, Stratos Division, Fairchild Engine and Airplane Corporation. Formerly, Assistant to Technical Director, NEPA Division, Fairchild.

Robert H. Ward (T.M.), Design Test Engineer, Minneapolis-Honeywell Regulator Company. Formerly, Junior Aerodynamicist, Chase Aircraft Company, Inc.

Earl T. Wegner (T.M.), now Engineering Draftsman, North American Aviation, Inc.

Eldad Wertheim (T.M.), now Design and Testing Engineer, Comprehensive Designers, Inc.

KEY POSITION WITH CONVAIR

A. P. Fontaine (A.F.) has been elected Vice-President and General Manager, Consolidated Vultee Aircraft Corporation. A 1930 graduate of New York University with a B.S. degree, he was with Convair previously from 1939 to 1945. Late in 1945, he became Director, Aeronautical Research Center, University of Michigan, from which position he resigned to return to Convair. In the past, Mr. Fontaine was also associated with Bendix Aviation Corporation as Director of the Experimental Aircraft Division, with Republic Aircraft Corporation as Project Engineer, and with Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation, as Aircraft Designer.

Again the time has come 1943

to ask your company,

and every company, to

Get in the 1951 SCRAP

FOR every ton of ingot steel produced, at least a half-ton of iron and steel scrap must have *previously* reached the furnaces. Steel is currently being produced at full capacity, more than 100 million ingot tons annually—and there is a developing scrap shortage of serious proportions. Just as in the early years of World War II, the steel industry asks the help of *all* industry to relieve the situation.

TWO IMPORTANT THINGS TO DO

(1) CLEAN OUT YOUR PLANT SCRAP. This is a job that every company can do. Old, worn-out or out-moded and replaced machinery and equipment, rails, structural parts, etc. constitute the "heavy melting scrap" which the steel industry needs most. Clean up *your* plant and yards—move out this heavy scrap into the channels of use.

(2) HURRY BACK YOUR WORKING SCRAP. Don't let the waste of metal-working—turnings, borings, punchings, crop ends, etc.—lie around the plant a day longer than necessary. Keep it moving, back to the furnaces. And doubly important, *be sure to classify and segregate your alloy steel scrap.* Thus handled, it not only commands a higher price, but will help to conserve the nation's supply of critical alloys, practically all of which are highly essential.

Contributed in the National Interest by

ALLEGHENY LUDLUM STEEL CORPORATION

Henry W. Oliver Building • Pittsburgh 22, Penna.

W&D CL 3617

Necrology

Horace A. Campbell

Horace Allen Campbell, M.I.A.S., passed away on October 27, 1950, at the age of 46.

Born in Tappen, N.D., Mr. Campbell attended the Riverside Junior College for 2 years and California Institute of Technology for 3 years, graduating from the latter in 1929 with a B.S. degree in Engineering.

From 1931 to 1939, Mr. Campbell was employed as a Civil Engineer with the Metropolitan Water District of Southern California, Los Angeles. In 1939, he took advantage of the various aeronautical courses he had taken at Cal Tech and became associated with Douglas Aircraft Company, Inc., as Strength Tests Engineer. At the time of his death, he was working at Douglas' El Segundo Plant.

Mr. Campbell is survived by his widow, Mrs. Luana M. Campbell, and a son, Jack.

Ensign Charles Dobony

Ensign Charles Dobony, U.S.N., T.M.I.A.S., died on February 16, 1951. He was 24 years of age.

A native of Buffalo, Ensign Dobony became a student at the Massachusetts Institute of Technology where he was also enrolled in the Naval V-12 class. Upon being graduated from M.I.T. in 1946 with a B.S. degree in Aeronautical Engineering, he was commissioned an Ensign in the U.S. Naval Reserve. During the ensuing period from March to July, 1946, he was assigned to the Research and Development Division, Bureau of Aeronautics, as an Assistant Design Evaluator.

When Charles Dobony received an appointment to the U.S. Naval Academy, he resigned his Naval Reserve commission and matriculated at Annapolis in 1946 as a Midshipman. He was graduated from there last year with a B.S. degree in Electrical Engineering and went on to the Naval Air Station at Pensacola, Fla., for flight training.

Ensign Dobony is survived by his mother, who resides in Buffalo

Corporate Member News

• **AiResearch Manufacturing Company, Division of The Garrett Corporation** . . . It has been announced that Murray S. Gelber, Vice-President and Secretary of The Garrett Corporation, has been appointed Vice-President and Manager of the AiResearch Manufacturing Company of Arizona, another Garrett division.

• **Allis-Chalmers Manufacturing Company** . . . The construction of a new plant with approximately 400,000 sq.ft. of floor space available for production compressors for the Wright J-65 Sapphire turbojet engine has been announced. The new building will be located on a 200-acre tract of land recently purchased at Terre Haute, Ind. The cost will be in excess of $5,000,000.

• **Aluminum Company of America** . . . A new Alcoa-developed high-strength aluminum alloy has been temporarily designated XA78S. Of the same aluminum-zinc-copper-magnesium family as Alcoa Alloy 75S, XA78S has approximately 10 per cent higher tensile and yield strengths with about the same elongation and fatigue properties. Limited tests, however, have indicated that the increase in mechanical properties of XA78S will involve some sacrifice in workability. This alloy is for the present being made available to plane builders for experimental and controlled production use only . . . A new aluminum smelting plant, capable of supplying 170,000,000 lbs. of aluminum annually, is being built at Wenatchee, Wash. It is hoped that the first aluminum can be produced there by August, 1952.

• **American Airlines System** . . . Coinciding with the introduction on April 29 of the first of 17 new DC-6B's are the addition of 60 new scheduled flights and the discontinuance of transcontinental sleeper service. It is not known when sleeper service will be resumed.

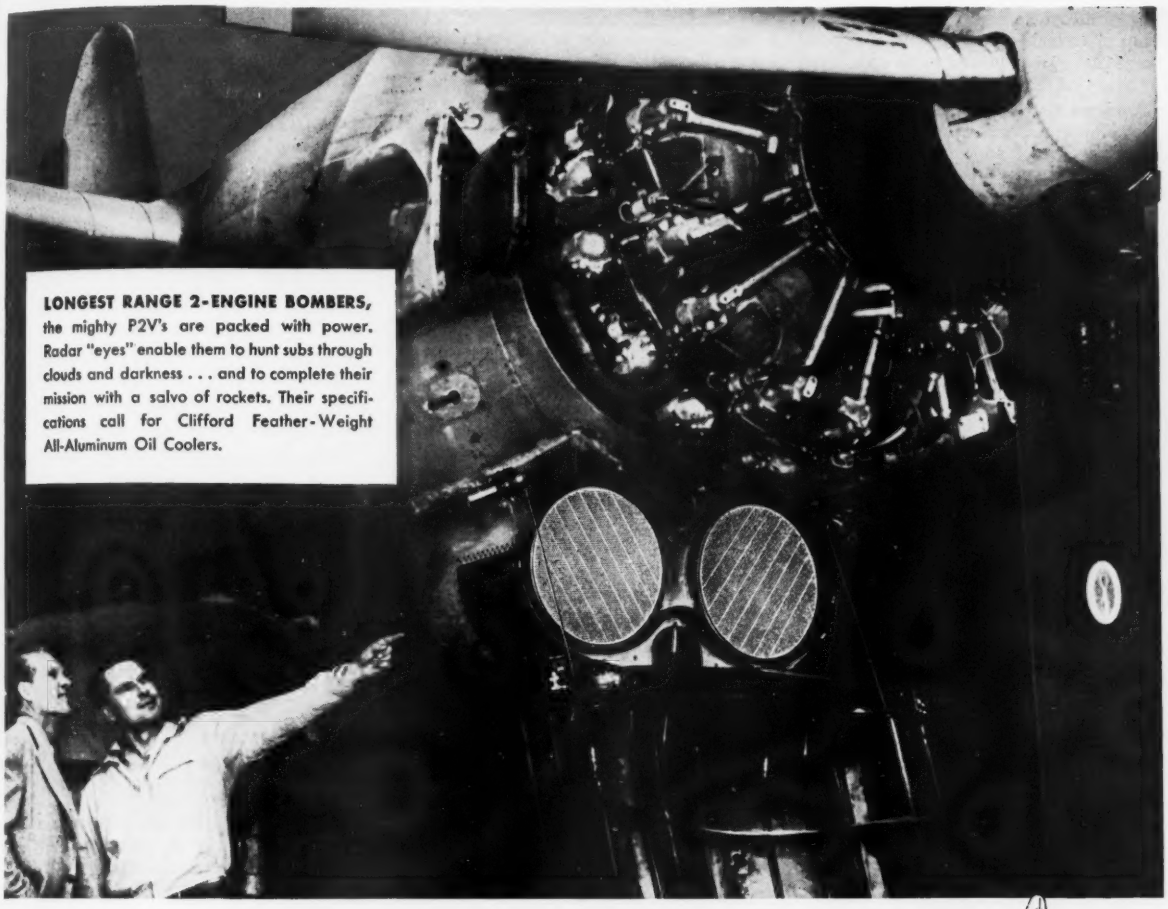
• **Bendix Radio Division, Bendix Aviation Corporation** . . . A tiny electronic amplifier, weighing less than 2 oz. and requiring only 35 component parts, has been developed in the Bendix research laboratories. This band-pass-type amplifier with a rated electrical gain of 130 db. is considered a major advance toward miniaturized air-borne radio equipment.

• **Boeing Airplane Company** . . . A new type of airplane model for wind-tunnel testing has been developed. Thin aluminum alloys, balsa-wood, and other lightweight materials are being put together by the model crew in such a way that the completed model has the same flexibility as the full-scale airplane would have. According to the report, this aeroelastic model is capable of providing both structural and aerodynamic answers not only for static conditions but for all cases of flutter and dynamic stability . . . C. B. Gracey was elected to the newly created post of Vice-President—Operations by the Board of Directors. Mr. Gracey has been Factory Service Manager at Boeing's Seattle Division for the past 3 years.

• **Boeing Airplane Company, Douglas Aircraft Company, Inc., and Lockheed Aircraft Corporation** . . . Representatives from Boeing, Douglas, Lockheed, and the U.S. Air Force recently completed preliminary planning for the Boeing B-47 Stratojet production on a tricompany scale. According to this program, the Boeing B-47 would be built "at some time in the future" by Douglas at its reactivated bomber plant at Tulsa, Okla., and by Lockheed at the reopened Marietta, Ga., plant. B-47 production schedules for Douglas and Lockheed have not yet been announced. Production of the swept-wing B-47 at Boeing's Wichita Division, however, is already under way. Boeing, as the designer of the B-47, will furnish engineering, tooling, and other technical information for the program and will be responsible for continued development and modification of the Stratojet series of airplanes.

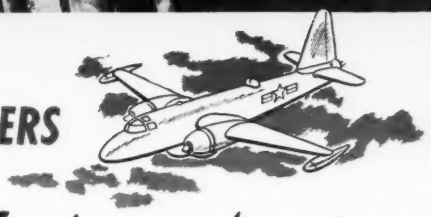
• **Consolidated Vultee Aircraft Corporation** . . . Convair and Southern Methodist University are jointly offering courses of study which lead to master of science degrees in engineering, with all classwork done in the aircraft plant itself. Believed to be the first such graduate study program instituted in the Southwest on an industry's site, the curriculum was begun on May 29 with an enrollment of about 35 graduate engineers. S.M.U. professors and qualified Convair engineers are teaching the program. Two degrees will be offered: Master of Science in Electrical Engineering with an option in electronics, and a Master of Science in Mechanical Engineering with an option in either structures or power plants.

• **Cornell University** . . . The new $1,700,000 center for the study of engineering materials, now under construction as part of a long-range engineering development program, will bear the names of two Cornell faculty members who pioneered in engineering education. The materials testing laboratory will be named Thurston Hall in honor of Robert H. Thurston, Director of Sibley College of Mechanical Engineering, Cornell, from 1885 until his death in 1903. The materials processing laboratory will honor Dexter S. Kimball,



LONGEST RANGE 2-ENGINE BOMBERS, the mighty P2V's are packed with power. Radar "eyes" enable them to hunt subs through clouds and darkness . . . and to complete their mission with a salvo of rockets. Their specifications call for Clifford Feather-Weight All-Aluminum Oil Coolers.

LOCKHEED'S P2V NAVY PATROL BOMBERS



Cool Their Oil With Feather-Weights

Modern aircraft of all types — conventional or jet powered — rely on Clifford Feather-Weight All-Aluminum Oil Coolers . . . *the only all-brazed type of oil cooler.* Famous Feather-Weights achieve a remarkable weight strength ratio thanks to Clifford's patented brazing method and accurate pre-testing in Clifford's wind tunnel laboratory . . . the largest and most modern in the aeronautical heat exchanger industry. Your inquiry is invited. CLIFFORD MANUFACTURING COMPANY, 138 Grove Street, Waltham 54, Massachusetts. *Division of Standard-Thomson Corporation.* Sales offices in New York, Detroit, Chicago, Los Angeles.

CLIFFORD

HYDRON Metal Bellows

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

now in retirement at 85, who was the first Dean of Cornell's College of Engineering. These units are expected to be completed in the spring of 1953.

• **Douglas Aircraft Company, Inc.** . . . The new DC-6B transport, the improved model of the four-engined airliner, was assigned type certificate No. 6A4 on April 11. The certification was for 100,000 lbs. gross take-off weight and 85,000 lbs. landing weight. With 91 of this model on order from 12 air lines, four of the 91 were to be delivered immediately after the certification—two to United Air Lines and two to American Airlines System . . . Leo A. Carter, M.I.A.S., General Manager, Santa Monica Plant, and T. E. Springer, General Manager, El Segundo Plant, have been elected Vice-Presidents. M. A. Kavanaugh, Chief Accountant, has been made Assistant Treasurer.

• **Elastic Stop Nut Corporation of America** . . . Two new designs in gang channel and anchor nuts, manufactured in conformance with Specification AN-366 and approved for use by aircraft manufacturers, have been introduced. Effecting substantial savings in weight with no sacrifice in strength, the new gang channel nut is 30 per cent lighter and the new anchor or plate nut is 25 per cent lighter than similiar E.S.N.A. fasteners now commonly in use.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation** . . . An experimental tandem-type gear has been installed on the C-119 Packets. Although it resembles the one currently used on production models of the C-119 in that it consists of the same essential strut arrangement, the axle carrying two side-by-side wheels has been replaced. In its place is a truck that has been mounted on a pivotal fitting on the main oleo strut that carries four wheels, slightly smaller than those now used on the production version. When the gear is fully extended, the front wheels are a bit higher than the rear ones, permitting the rear wheels to touch down first on landing. Nacelle doors have been modified to accommodate the bulk of the extra wheels. The purpose of the new gear is to increase the utilization of Packets for landing on unprepared fields with rough sod or soft surfaces . . . William Preston Lane, Jr., a former Maryland governor, has been elected a member of the Board of Directors.

• **The Firestone Tire & Rubber Company of California** . . . Rubber-fabric fuel cells that fit into the wings and fuselages of U.S.A.F. fighters and bombers are back in production. These fuel cells are self-sealing in the event of a bullet puncture.

• **General Electric Company** . . . A special 180,000-hp. motor unit that may well be the most powerful electric drive of its kind, is being constructed for the N.A.C.A. for installation in a new supersonic 8-ft. wind tunnel at the Ames Aeronautical Laboratory, Moffett Field, Calif. Although the drive consists of four 45,000-hp. 720-r.p.m. variable-speed a.c. induction motors mounted in tandem on a single shaft, G-E engineers believe the complete unit will have a peak 1-hour output of 216,000 hp. Two axial-flow compressors, each about 17 ft. in diameter, will be linked to the drive system of the motors and will produce supersonic air streams for actual testing. The system will use slip-regulator control. The N.A.C.A. has also ordered a second unit, rated at 110,000 hp., as a replacement for the 27,000-hp. G-E drive installed a few years ago in the present 16-ft. wind tunnel at Ames. This drive, comprising two 41,500-hp. and one 27,000-hp. variable-speed a.c. induction motors, will use the slip-regulator and Clymer-System speed control in combination . . . More than 80,000 sq.ft. are to be added to the 1,000,000-sq.ft. turbine plant in Schenectady, N.Y. Total estimated cost for the extension, new equipment, and rearranging facilities will be approximately $6,500,000 . . . A 16-page booklet, *GED-1406*, showing the facilities and work of the new $2,000,000 Measurements Laboratory of the Meter and Instruments Divisions, is now available from G-E, Schenectady 5.

• **The B. F. Goodrich Company** . . . The increased production of De-Icers, the pulsating rubber tubes, has resulted in the addition of several thousand feet of floor space as well as extra equipment . . . Construction on additional facilities for The B. F. Goodrich Research Center, originally opened in 1948, has been started. Completion is expected around this coming October . . . William S. Richardson, President, B. F. Goodrich Chemical Company, has been made a Vice-President of The B. F. Goodrich Company. Mr. Richardson will continue in his capacity as the chemical company's President.

• **The Goodyear Tire & Rubber Company** . . . A lightweight, inflatable jet-pod maintenance shelter has been developed. Made in two sections that are mounted on mated dollies for maneuverability, the portable shelter fits around one of the jet pedestals under the wings of a B-36 bomber. The suspended jet pod is thereby completely enclosed in a weather-proof structure that is 27 ft. long by 14 ft. high by 14 ft., 8 in., wide. The shelter is internally braced with a series of aluminum stiffeners interlaced with wire cable and is

ARCTIC RADAR DOME

This inflated rubber radar dome recently completed by The B. F. Goodrich Company for the U.S. Air Force will be used to house aircraft warning equipment being installed on the Arctic rim of the Western Hemisphere. Its specially compounded rubber and fiber-glass walls are made as thin as possible in order to get clear reception of radar signals without distortion. The structure itself measures 37 ft. in height and 54 ft. in diameter, contains over 60,000 cu.ft. of space, and is inflatable with an air pressure of less than 1 lb. per sq.in. The dome was constructed to withstand 120-m.p.h. winds and heavy accumulations of ice and snow. Other domes will use a nylon and rayon fabric.

What's doing at JACK & HEINTZ

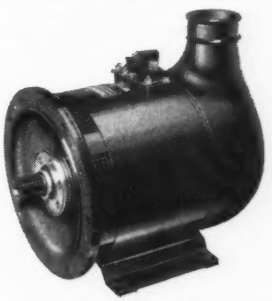
Alternators Offer Means to Boost AC Power Output

The large amounts of AC power required by modern aircraft have led to the use of engine-mounted alternators which are high in efficiency, thereby permitting a given airplane to have available the maximum amount of AC power with the least tax on engine output. Also, commutation and brush problems inherent in DC generators at high altitude are largely avoided, since the brushes and commutators used in the alternators may be utilized at much lower current densities than would be practical on DC machines.

By using alternators to generate AC power, the total installed electrical system weight may be reduced appreciably.

In addition to engine-mounted alternators, J&H has developed machines for use with air turbine drives, hydraulic drives, or other power sources. The current J&H line of aircraft alternators ranges from 3 KVA to 312 KVA, with both constant and variable-speed machines in most ratings. We also offer tailored designs for guided missile applications involving unusual cooling conditions and operating requirements.

J&H Alternators embody many years' experience in designing for specific aircraft applications. This design experience enables us to provide a maximum of performance with a minimum of weight and space.



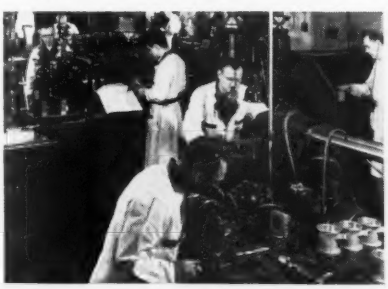
A representative J&H Alternator—the G90-1 Model—with a 15 KVA, 120 volt, single-phase rating.

90 Aviation Customers Served by J&H

In addition to our military customers—the Air Force, the Army and the Navy—we are listing below 90 major customers in the aviation industry who count on J&H *Rotomotive* devices to perform vital functions in their equipment.

Commercial Air Lines — Domestic	24
Commercial Air Lines — Foreign	17
Airframe Manufacturers	16
Aircraft Engine Manufacturers	6
Aviation Equipment Manufacturers	25
Research & Development Centers	2

J&H moves fast to give you working models!



In this complete model building shop in the engineering laboratory, J&H takes designs off the boards and *makes them work*. Finished parts are fabricated and checked carefully against specifications. They are then precision assembled into electrical, hydraulic or mechanical prototypes for thorough experimental testing. Individual initiative and flexibility enable J&H engineers to *get at your problem faster . . . give you the working Rotomotive prototypes you require.*

CHIEF ENGINEER'S CORNER

Many customers have asked us for quotations on special types of alternators—cascade, induction, and the like. Our company has built several models of these, gaining experience that is invaluable in determining the best type of alternator for a specific purpose.

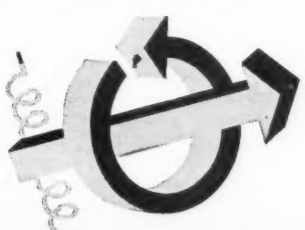
In general, there are no "trick" machines that solve *all* of the fundamental problems we encounter. Each type of machine has its advantages and its disadvantages.

Often, we are asked to quote on a specific type of machine, but after learning more about the application, we find that another type is better suited.

Usually these situations arise from a misunderstanding of the brush problems involved at high altitude. Many advances have been made in the treatment and application of brushes, especially as applied to alternators. It is a rare occasion where we find it necessary to provide a "brushless" alternator design with its inherent disadvantages.

We hope our customers will provide us with a maximum of application and environment data. We will then be in a position to choose the best type and design of machine to meet your requirements. Write JACK & HEINTZ . . . Cleveland 1, Ohio.

JACK & HEINTZ *Rotomotive* EQUIPMENT



means electrical, hydraulic or mechanical devices designed to solve unusual problems of developing power, controlling it, or using it.

DECELERONS FOR THE F-89

Engineers at Northrop Aircraft, Inc., have designed a jaw-like deceleron for the F-89 Scorpion. This type of control surface can act either as an aileron or a fighter brake. In normal flight, the jaws (shown open in the picture) are closed and function together as an ordinary aileron; in dives, these jaws are fully opened for braking effect. The jaws, opened as a fighter closes in on a target, are said to reduce speed long enough to permit firing, after which they are closed and the ship scampers away. The F-89's are armed with a cluster of six 20-mm. cannon.

designed to withstand a wind load of 70 m.p.h., when moored, and a snow load of 30 lbs. per sq.ft. The material used in its construction is a 2-ply nylon fabric coated with a synthetic rubber; the plies themselves are separated by 2- to 3-in. dropped pile threads. The complete structure can be inflated with only 10 lbs. of air pressure. Both shelter and dolly are designed for compact packaging for air shipment and for rapid assembly. A similar shelter will also be produced for the B-47 bomber.

• **The Goodyear Tire & Rubber Company and A. V. Roe Canada Limited** . . . Goodyear electrothermal deicing pads, known as Iceguards, have been fitted on the leading edges of the wings and empennage of the Avro Jetliner. The deicers were designed by Goodyear's aviation specialists in cooperation with the National Research Council. The N.A.C.A. laboratory in Cleveland ran tests on the Jetliner's new equipment as part of this country's C.A.A. and Canada's Department of Transport requirements for certification.

• **Lear, Incorporated** . . . Paul Moore has been elected Executive Vice-President and General Manager.

• **McDonnell Aircraft Corporation** . . . Kendall Perkins, A.F.I.A.S., who was formerly Manager of Engineering, was made Vice-President—Engineering.

• **Meletron Corporation** . . . Development of pressure-actuated switches for rocket-engine applications has been initiated under a Research and Development contract recently awarded by Air Materiel Command. The project's principal objectives are resistance to extreme vibration, ability to withstand wide temperature ranges, and greater sensitivity and accuracy.

• **North American Aviation, Inc.** . . . The AJ-1 bomber has been given the name of "Savage" by the Navy. This particular name was submitted by the late Lt. Comdr. Clyde Fairless, Flight Surgeon, Composite Squadron VC-5, who died in line of duty between the time he submitted this suggested name and the time it was chosen as the winner among 43 submitted.

• **Northrop Aircraft, Inc.** . . . A four-burner jet engine was designed and developed by Northrop Aeronautical Institute students by modifying a P-38 supercharger. This small-scale centrifugal turbojet engine, representing 2 years of research, is capable of powering a light plane and in design is similar to the J-33 jet engine. It weighs 168 lbs. and develops a total of 320 lbs. (calculated) static thrust.

• **The Parker Appliance Company** . . . O-rings and other precision molded seals in a newly developed synthetic rubber compound (Parker 42) are now obtainable. Parker 42 is said to function effectively in sealing performance anywhere in the temperature range of −85° to +275°F.

• **Piasecki Helicopter Corporation** . . . Gareth W. Speer, formerly with Kaiser-Frazer, has been named Treasurer.

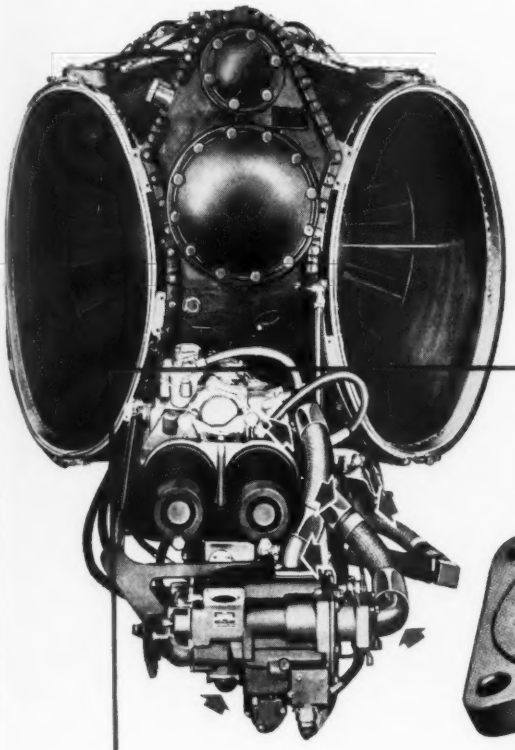
• **Pratt & Whitney Aircraft Division, United Aircraft Corporation** . . . In the production of the J-48 Turbo-Wasp turbojet engine, it is said that the use of materials unavailable in the western hemisphere has been avoided. Of three critical materials—columbium, cobalt, and tungsten—columbium has been eliminated, while cobalt and tungsten have been reduced to only a small trace of a fraction of a pound per engine. Columbium is available only in Nigeria; there are small deposits of the other two materials in North and South America.

• **Republic Aviation Corporation** . . . As part of an expansion program, a branch engineering office has been opened at 99 Church Street, New York City.

• **Servomechanisms, Inc.** . . . Since May 1, the main office and home plant have been located on a two-acre landscaped plot near the intersection of Post and Stewart Avenues, Westbury, L.I., N.Y. This new site includes, in addition to parking facilities, a main building and annex which provide 36,000 sq.ft. of available floor area. Thirty thousand square feet have been allocated to engineering and production; the remaining 6,000 sq. ft. are given over to the general office. The Westbury plant is continuing its design activities in the electronic and electromechanical fields. As part of an expansion and decentralization program, a Southeastern production plant and office were established recently at Fort Lauderdale, Fla. There is also a Pacific Coast liaison service office at the Los Angeles International Airport.

• **Stratos Division, Fairchild Engine and Airplane Corporation** . . . A new $2,000,000 plant that will contain approximately 125,000 sq.ft. of floor area is to be constructed on a 24-acre site by the Long Island Railroad, Bay Shore, L.I., N.Y. It will be used for the manufacture of aircraft refrigeration and pressurization units and other aeronautical accessories. The factory portion of this new structure will be one story high; the engineering and general office section will be two stories high. The building will be ready for occupancy in November.

Fitting for Fighting Planes...



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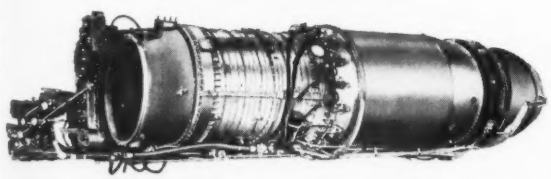

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• **Shell Oil Company** . . . According to a Shell Fellowship Committee announcement, twelve Fundamental Research Grants, initiated last year, will be extended for a second year and will total $60,000. The new research grants supplement Shell's Graduate Fellowship Program of 45 fellowships, totaling $75,000 annually, which also remains unchanged for 1951–1952. Fundamental Research Grants have been awarded to California Institute of Technology, Carnegie Institute of Technology, University of Chicago, Harvard University, Massachusetts Institute of Technology, Princeton University, Stanford University, and Yale University. The main proviso on these grants is that they be utilized directly for fundamental research in the field designated. With regard to the Graduate Fellowship Program, students recommended by the college as Shell Fellows receive a stipend of $1,200 for the academic year; their tuition and fees are paid; a special fund of $300 is allocated to each school for related research expenses of the fellow. Fellowship preference is given to candidates in their final year of Doctorate study.

• **United Air Lines, Inc.** . . . A new jig that uses hydraulic pressure in restoring rings to proper shape has been developed at the San Francisco maintenance base. It is said to simplify greatly the overhaul assembly of exhaust collector rings for the R-4360 engines.

• **Westinghouse Electric Corporation** . . . A new Air-Arm Division has been formed that will occupy a new 400,000-sq.ft. plant to be built on the recently purchased 75-acre tract of land at a corner of Baltimore's Friendship Airport. Completion of this new plant, which will include offices and an engineering laboratory, is expected by autumn. By the end of this year, this division should be turning out automatic computers to direct gun and rocket fire, radar and autopilots for fighter planes and guided missiles, and complete air-borne armament systems . . . Plans for the construction of an electronic-tube manufacturing plant on a 70-acre site in Bath, N.Y., has been announced. The structure, when completed, will provide three acres of floor space for manufacturing and warehousing. Headquarters of the Electronic Tube Division will be at the large plant near Elmira, N.Y., for which plans for construction were recently announced. There will also be engineering laboratories at the Elmira plant . . . For copies of a new 28-page booklet (B-4739) on "Westinghouse Large Induction Motors" write to Box 2099, Pittsburgh. Among other things, this booklet presents a quick summary of the types and features of the two basic kinds of induction motors: Type CSF squirrel-cage motors for constant-speed drive and Type CWF wound-rotor motors for adjustable-speed drive.

I.A.S. Sections

Boston Section

L. J. Nuttall, *Secretary*

The members of the Boston Section were treated to a talk by R. Dixon Speas, U.S. Representative, A. V. Roe Canada Limited, on "Operational Aspects of Turbojet Transports" at the April 11 meeting held at the Massachusetts Institute of Technology.

Mr. Speas started his talk by filling in some of the background of the Avro Jetliner and then showed motion pictures of some of the flight testing of the plane. He went into a candid discussion of the pros and cons of the turbojet power plant for transport planes as compared with the reciprocating engine. He then presented operational flight data taken over regular air-line routes and compared these results with data from the air lines' planes taken the same day. Some of the main advantages of the jet-powered transport are faster schedules, less noise and vibration, and smoother flying at higher altitudes; the main disadvantages are slightly higher fuel costs and more frequent overhauls.

The members present enjoyed Mr. Speas' talk and were convinced that the turbojet has a place in the commercial transport business.

Chicago Section

Alfred Scott, *Secretary*

The annual joint meeting with the A.S.M.E. was held on April 17 in the facilities of the Western Society of Engineers. A brief social period preceded the dinner.

The meeting was called to order at 8:00 p.m. by Mr. McNaulty of the A.S.M.E. Forty-eight members and guests assembled to hear Albert Gail of Cornell Aeronautical Laboratory talk on "The Development of the Helicopters" as well as problems encountered in their design and fabrication.

Mr. Gail has been associated with helicopter work for a long time and was one of the pioneers of McDonnell's "Little Henry." He spoke about many interesting conditions, comparing rotors driven by ram-jets to those mechanically driven. It was shown that the ratio of useful load to the gross load can be materially improved with ram-jets and with simpler controls. The simpler control could be accomplished by tilting the main shaft and eliminating the swash plate. An interesting question and answer session followed the talk. Mr. McNaulty closed the meeting.

Dayton Section

Major W. A. Barden, *Secretary*

On April 26, approximately 50 members attended a lecture presented by Dr. Heinz E. Schmitt, Office of Air Research, who spoke on the subject, "Afterburning Without Afterburners."

Hagerstown Section

Robert A. Darby, *Secretary*

A dinner meeting was held on April 17 at the Hotel McLaughlin, Greencastle, Pa. S. Paul Johnston, I.A.S. Director, and Robert R. Dexter, I.A.S. Secretary, were guests of the Section for this meeting to which wives were invited. Rear Adm. Lawrence B. Richardson, U.S.N. (Ret.), I.A.S. President, a member of the Hagerstown Section and Director of Research and Development, Fairchild Engine and Airplane Corporation, attended. Guest speaker of the evening was T. E. Newbold, Jr., General Manager, Stratos Division, Fairchild Engine and Airplane Corporation. Robert D. Gilson, Section Chairman, presided.

Mr. Johnston extended the greetings of the Institute to the Hagerstown Section. The floor was then given over to Mr. Newbold for the subject, "Air Cycle Refrigeration Systems for Aircraft." Mr. Newbold reviewed existing requirements for cockpit pressurization and cooling, suggested possible growth of these requirements, and reviewed the thermodynamic principles of refrigeration using air as the working fluid. After a discussion of simple and regenerative systems of refrigeration, he passed on to the problems of mechanical design, especially those of the turbine. Cutaway models of the Stratos NUR60 refrigeration unit for jet aircraft cockpits and of the S60 cabin supercharger facilitated a discussion of the manufacturing problems involved.

The meeting was attended by 45 members and guests.

Montreal Section

G. E. Otter, *Secretary*

The Montreal Section held a joint meeting with the Montreal Section of the S.A.E. on April 17. Approximately 180 people attended the meeting. John Drummond, I.A.S. Section Chairman, introduced the speaker. Igor I. Sikorsky, Engineering Manager, Sikorsky Aircraft Division, United Aircraft Corporation, addressed the meeting on the subject, "The Role of Helicopters in Peace and War."

Mr. Sikorsky discussed some of the problems and trends associated with the future development of helicopters. He compared the single- and multirotored helicopters and pointed out that the

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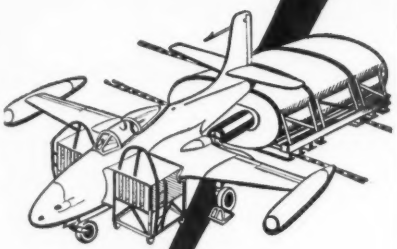

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airplane designer had long ago discarded the structurally efficient multi-wing designs in favor of the structurally inefficient but aerodynamically efficient monoplane. He expressed the opinion that single-rotored designs would be generally adopted to avoid penalties and complications due to vibration, interference, etc.

With regard to the maximum size of the helicopter which could be designed, Mr. Sikorsky foresaw no upper limit. One-hundred-seaters are entirely feasible. The weight cube law applies no more to the helicopter than it did years ago to airplanes when it was forecast that the maximum possible gross weight of an airplane was one ton.

Mr. Sikorsky believed that the upper cruising speed of the helicopter would be approximately 175 m.p.h. By using a fixed wing for cruising and a rotor for slow speed or by the use of the convertaplane, the upper speed limit could be made to approach that of conventional aircraft. He thought that the use of propulsion units mounted on the rotor would have considerable use particularly for specialized uses but that the greater proportion of helicopters will retain the transmission.

Protection of the rotor against icing is still a problem and there has not been a helicopter built as yet with adequate protection for all-weather flying. The early optimism that centrifugal force would keep the rotor free of ice has not been born out.

Mr. Sikorsky showed two films illustrating some of the uses as well as the maneuverability of the helicopter and concluded by answering numerous questions from the floor.

Pittsburgh Section

R. H. Fields, *Secretary*

On April 3, at 8:00 p.m., at the Mellon Institute, the meeting was called to order by Chairman G. F. Towner with 11 members and 23 guests present. After announcing the meetings remaining on this season's schedule, the speaker, Adm. Lawrence B. Richardson, I.A.S. President and Director of Research and Development, Fairchild Engine and Airplane Corporation, was introduced. Admiral Richardson's topic was "The Evolution of Cargo Planes."

The Admiral pointed out that, during World War II, although there were many converted transports used for cargo planes, there were no real cargo planes. As a result, it was common practice to have to disassemble or cut up large pieces of equipment in order to get them into the converted transports. Loading and unloading constituted the majority of the time consumed in air carrying of cargo by large factors. Al-

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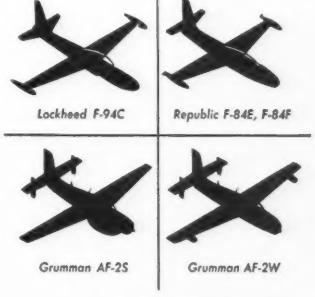

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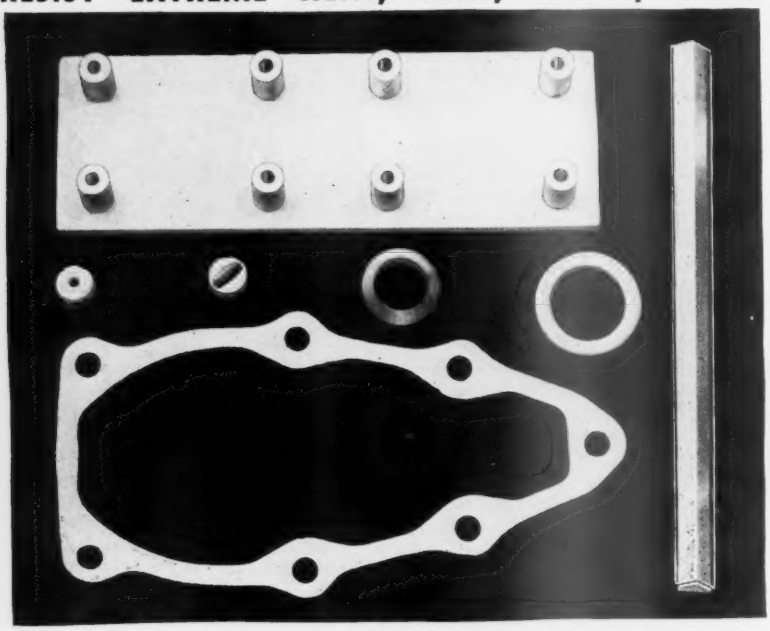

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though none of the present-day cargo planes saw action in World War II, their need was recognized, and production of cargo planes began at that time. Since World War II, large strides have been made in the development of cargo planes, including such innovations as the detachable cargo pod. At the conclusion of the talk, four films of Fairchild cargo planes were shown. The films illustrated the ruggedness, ease in landing, and performance of several Fairchild cargo planes.

San Francisco Section

John A. Stern, *Chairman*

The following officers were elected for 1951 and have taken office: Chairman, J. A. Stern; Vice-Chairman, Prof. Volney C. Finch; Secretary, Donald R. Jacoby; and Treasurer, Gerald H. Backer.

The meeting of April 5 was held at Ramor Oaks in Palo Alto with 75 members and guests attending. The guest speaker was Dr. Karl Klotter, Associate Professor of Engineering Mechanics, Stanford University. Dr. Klotter is engaged in research on nonlinear vibrations and lectures on nonlinear mechanics. He received the degree of Diploma Engineer in 1925 and the degree of Doctor Engineer in 1929 from Technische Hochschule Karlsruhe in Germany.

Preceding the dinner, Douglas Aircraft Company entertained the members and their guests at cocktails. Following the dinner, the chairman outlined future meeting plans, old and new business was discussed, and then the guest speaker was introduced.

The evening's lecture began with Dr. Klotter's tracing the modern vibration theory from DeLaval's work with high-speed turbines in 1883 to the present. He proceeded to discuss the modern vibration theories, which he proved with mathematical computation. The talk was highlighted by a series of unique vibration models that clearly showed the audience the various points discussed. Professor Klotter then turned to practical cases such as compass error caused by vibration which may amount to as much as 180° and wing flutter as well as the effects of vibration on aircraft engine shafts and means of counteracting the vibration hazards.

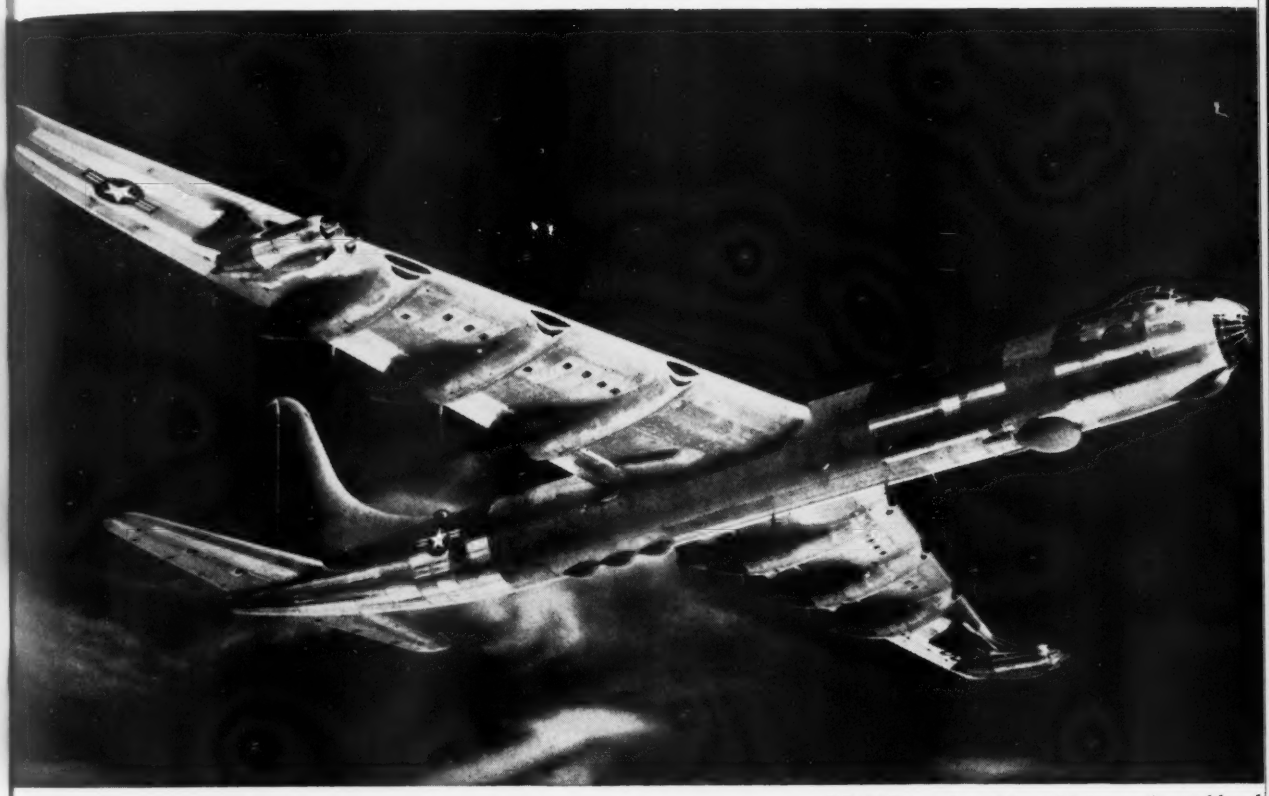
At the close of the lecture, Dr. Klotter joined with members in an enthusiastic informal discussion.

Texas Section

Roland Christy, *Secretary*

A closed meeting was held on April 26 at Chance Vought Aircraft Division, United Aircraft Corporation, at Grand Prairie.

Take a look at the CONVAIR B-36...



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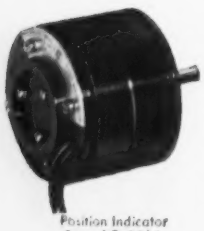

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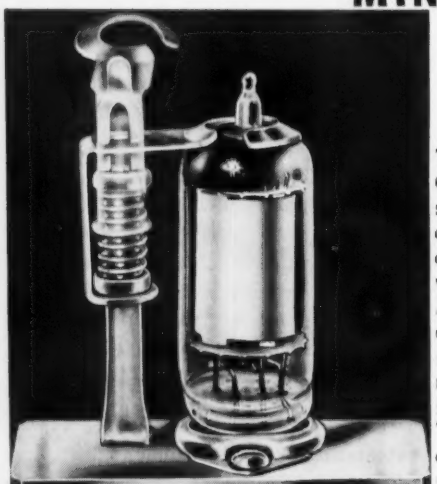

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The meeting was opened by Chairman E. Kurzawa who introduced the guests, officers, Advisory Board, and committee members of the Texas Section. Among the guests was E. W. Robischon, I.A.S. Western Manager.

C. F. Blanding, Staff Technical Assistant, AiResearch Manufacturing Company, chose as his subject, "Pneumatic Power for Aircraft." Mr. Blanding discussed the various systems used for engine starting and auxiliary power and the development of pneumatic systems for these applications.

Toronto Section

S. L. Britton, *Secretary*

The April 12 meeting was opened by Chairman H. C. Luttman who described the May field trip (for members only) to the R.C.A.F. Aeronautical Medical Centre in Toronto. Mr. Luttman then asked Boyd Ferris of the Publicity Committee to introduce the guest speaker.

Mr. Ferris briefly reviewed the meteoric career of the guest speaker, R. Dixon Speas. Mr. Speas is the A. V. Roe Canada Representative in the United States and Chairman of the I.A.S. New York Section. The speaker, a graduate of Boeing School of Aeronautics and Massachusetts Institute of Technology, started his career in the Engineering Department of American Airlines, and was later placed in charge of engineering and maintenance of the Contract Air Cargo Division. At the time of his resignation from American Airlines last year, he was Special Assistant to the President.

Mr. Speas started his talk, "Air Cargo," by systematically outlining the subject under the following headings: (a) general statics of air cargo today, (b) the history of air cargo; (c) handling of cargo; (d) method of loading cargo in aircraft; and (e) summary and future of air cargo.

It was pointed out that aircraft as a means of transporting cargo have increased in popularity so much that during last year as many ton-miles of cargo were carried as there were passenger ton-miles in 1944. The speaker showed statistics proving that many commodities, including live stock, could easily be transported by air at considerable saving to the shipper, since the time saved and the condition of the load on the arrival at destination were to his advantage.

The speaker showed pictures of various types of aircraft used over the past few years in cargo work and explained the advantage and disadvantage of using aircraft that have been specifically designed for this work.

Mr. Speas showed the vast organizations required to maintain efficient

cargo service that could compete with the conventional types of shipping. It was shown that a great deal of the advantage given by the speed of the aircraft was lost because of the time spent in handling and the time spent in transporting the cargo to and from the airport.

The speaker maintained that a great deal of time had yet to be spent on the organizing of Air Cargo Services so that the pick-up system, loading system, aircraft stowage, and scheduling could be improved to the point where a minimum of time is lost in their function. This would enable the aircraft to be utilized to the utmost.

The speaker then became more specific about the loading of the aircraft, going into the pros and cons of the various space utilizing schemes that had been proposed. He also described a means of segregating the cargo to permit easy unloading on a multiple stop flight. Problems of cargo densities, aircraft door sizes, loading techniques, and special equipment were discussed with special reference being made to the many types of specially designed loading docks that are presently being used and some scheduled for future use.

The speaker concluded by discussing many aspects of shipment by air which were not commonly known and dispelled the "bogie" of rigid temperature and ventilation control which has supposedly limited the use of air cargo for the majority of commodities in the past. Mr. Speas said that he felt that the greatest advances in the air-cargo transport would be made with the advent of pressurized cabins, economical turboprop engines, and 6,000- to 8,000-ft. runways that are required for full-load take-off.

The speaker was thanked by W. H. Jackson, of de Havilland, who reviewed briefly the attempts in this country to improve the design of cargo aircraft. He also thanked Mr. Speas for his favorable comment on the Canadian D.H. Beaver that is being received with such interest in the United States.

Student Branches

University of Alabama

William O. Armstrong and Kendall Gustafson, both U. of A. students, presented illustrated talks on the "Production and Uses of Titanium" and "Velocity Variations in the Boundary Layer" at the April 10 meeting. Student Chairman, Major Mortimer D. Marks, U.S.A.F., presided; 20 persons were present.

Dr. August Raspet, Research Associate at Mississippi State College, gave an illustrated lecture on "The Possibility of Human-Muscle-Powered Flight" before the 34 persons attending the April 24 meeting. Chairman of the Branch, Major Mortimer D. Marks, U.S.A.F., presided.

University of California

On April 13, Jim Kite, representing the World Student Service Fund, gave a talk on the "Distribution of World Student Service Fund." Chairman Lee W. Groner presided.

On April 15, 11 Student Members attended the San Francisco Section meeting and heard Dr. William Bollay, Technical Director, Aerophysics Laboratory, North American Aviation, Inc., lecture on "Aerodynamic Stability and Automatic Control."

University of Cincinnati

On May 3, a Bell Aircraft Corporation film entitled *Report on Jet Propulsion* was shown. Chairman Dale H. Whitford presided; 27 persons were present.

Clarkson College of Technology

Two N.A.C.A. films were shown at the April 4 meeting at which Chairman Robert C. Waters presided. The pictures shown were the *Effect of Air-Fuel Ratio on Combustion in a High-Speed Compression-Ignition Engine* and *Slow-Motion Study of Normal Combustion, Preignition, and Knock in a Spark-Ignition Engine.* Twenty persons were present.

William C. Martin, a Junior in Mechanical Engineering, spoke on "Aerodynamic Considerations of Racing Hydroplanes" at the April 18 meeting. Two films, *How Not to Conduct a Meeting* and *Where Mileage Begins,* were shown. Vice-Chairman Louis Manno presided; 12 persons were present.

On May 2, Roger A. Krey, Instructor, Mechanical Engineering, Clarkson, spoke on "Gliders in World War II." Fred Whitehouse, a former B-24 pilot-navigator, gave a short talk about the flight that supplied the Rhine crossing and his own part in that mission.

Elections for the 1951–1952 officers were held with the following results: Chairman, William C. Martin; Vice-Chairman, Willis S. Rice; Secretary, M. S. Day; and Treasurer, J. H. Smith.

Three films shown on this occasion included *ABC of Internal Combustion, Ignition in the Internal-Combustion Engine,* and *ABC of Automobile Engines.*

University of Colorado

Percy Miller, an Aeronautical Department Instructor, spoke on "Glider Towing" at the April 12 meeting. There were 23 persons present; Chairman Myron J. Miller presided.

On April 17, a combined meeting of mechanical, civil, and electrical societies was sponsored by the I.A.S. Student Branch. The speaker for the occasion was Arn Sorenson, Project Engineer, Boeing Airplane Company, who delivered a lecture on the "Development of the B-47." A film, *The 502 Gas Turbine Engine,* concluded the meeting. Chairman Miller presided; 51 persons were in attendance.

The new officers who were recently elected are as follows: Chairman, Burtis Roy Benson; Vice-Chairman, A. W. McFarland; Secretary, Dorothy Jane Judge; and Treasurer, Borden John Burleson. Professor K. D. Wood is Faculty Adviser.

University of Detroit

On April 16, Joseph Conway, a Student at the University, presented his paper on "The Conway Convertaplane." Mr. Conway is planning to present this paper at the Tri-University speech contest. Chairman Donald R. Lapworth presided; 16 persons were in attendance.

An election of officers was held at the April 16 meeting with the following results: Chairman, George Paul Himes; Vice-Chairman, Thomas E. Stuck; Secretary, Charles J. Stim; and Treasurer, John L. Shea.

University of Florida

On April 3, the 25 attending members heard Frank S. Miles, Representative of Sperry Gyroscope Company, lecture on "Sperry Instruments." Chairman Costa Francisco presided.

University of Illinois

Chairman Corliss Laisure opened the May 2 meeting at which an election of officers was held and competitive papers for the annual I.A.S. Lecture Award were read. There were 27 persons present.

The following men were elected to office: Chairman, William Greenfield; Vice-Chairman, Loren Anderson; and Secretary-Treasurer, Donald Pfeuffer. H. H. Hilton was elected as the new Faculty Adviser.

Student Members James Watson and H. A. Wallskog presented their competitive papers. Mr. Watson, this semester's Vice-Chairman, spoke on "Design Problems for Roadable Aircraft." Mr. Wallskog talked on the "Design Problems of Supersonic Flight." Mr. Watson's paper was voted the winner of this year's annual I.A.S. Lecture Award.

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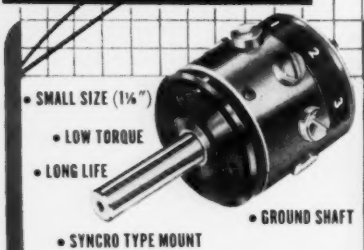

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Iowa State College

Seventeen students present at the May 2 meeting reelected Carl N. Sanford as Honorary Chairman. Chairman Eugene Dandy presided.

Kansas State College of Agriculture and Applied Science

A new I.A.S. Student Branch has been formed here with a membership of 14 students. Officers who have been elected for the remainder of the 1951 spring semester are: Chairman, Raymond G. Sharp; Vice-Chairman, Delmer W. Hrabe; and Secretary-Treasurer, John L. Law. Professor Frank J. McCormick was elected Honorary Chairman.

Lawrence Institute of Technology

On April 13, Student Member Richard Traczyk presented a paper on the "Modification of the Spirit of Lawrence Tech." This lecture was given in preparation for its final delivery at the Fourth Annual Student Award Contest and Dinner sponsored by the I.A.S. Detroit Section. Chairman John A. Mayott presided at the paper's initial presentation; 11 persons were present.

On May 3, the Fourth Annual Student Award Contest and Dinner got under way with papers being presented by Arthur G. Bennett, University of Michigan; Joseph Conway, University of Detroit; Ronald Barcus, Wayne University; and Mr. Traczyk, Lawrence Institute of Technology. The contest was won by Mr. Bennett, who spoke on "Aerodynamics, Missiles, and Home Runs." Mr. Bennett received a Student Branch Plaque and an individual award of $50. The other contestants each won $10. Fifty-two persons were present.

Louisiana State University

An election of officers for the coming year was carried out at the May 3 meeting with the following results: Chairman, Jack Cantrell; Vice-Chairman, Lane Barnette; and Secretary-Treasurer, Jerry Carpenter. Chairman Robert Dawson presided; 8 persons were present.

University of Maryland

Two C.A.A. films, *Forces on an Airfoil* and *Aircraft Power Plants*, were shown at the April 4 meeting of this new Student Branch.

On April 12, three additional C.A.A. films were shown. They included the *Northrop Flying Wing*, *Airplane Structures—Wing Contruction*, and *Airplane Structures—Alighting Gear*. Chairman William S. Bissell presided; 15 persons were present.

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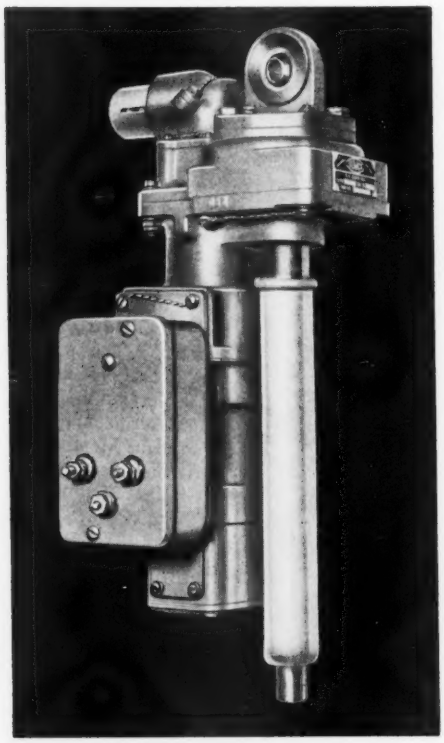

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Massachusetts Institute of Technology

A film, *History of Naval Aviation*, was shown at the April 24 meeting. Chairman Alfred Blackburn presided; 36 persons were present.

University of Minnesota

On January 17, Dr. Rudolf Hermann, Professor at Minnesota, described in an illustrated lecture the "Development of Guided Missiles in Germany." Chairman James P. Lindberg presided; 35 persons attended.

An "Aero Ball" was held on February 21 and proved to be a financial and social success.

The April 18 meeting was led by Chairman James P. Lindberg. Ken Anderson, Scientist, Rosemount Research Center, University of Minnesota, and Walter Bradfield, Lecturer, University of Minnesota and Rosemount Research Center, presented a lecture on the "Facilities and Projects of the University of Minnesota's Rosemount Research Center." Twenty-two persons were in attendance.

New York University

On April 28, under the Chairmanship of James A. Miller, 25 I.A.S. Student Members participated in the campus-wide Engineering Demonstration Day at which high school students from New York and vicinity were conducted through the facilities of the College of Engineering. I.A.S. Student Members served as guides and lecturers for the exhibitions in the Guggenheim School of Aeronautics.

North Carolina State College

Under the Chairmanship of Reese Folb, the following officers were elected for the coming year at the March 27 meeting: Chairman, Arthur A. Crews; Vice-Chairman, Jack E. McCormick; Secretary, William E. Broach; and Treasurer, William C. Parks. Seventeen persons were present

Chairman Arthur Allan Crews led the May 1 meeting at which 18 persons viewed the film, *Guided Missiles*.

Northrop Aeronautical Institute

With 78 persons present at the May 2 meeting, Fred H. Felberg gave an illustrated talk on the Southern California Cooperative Wind Tunnel. Mr. Felberg is Chief of the Operations Section, C.W.T. Chairman J. C. Chaffee presided.

University of Notre Dame

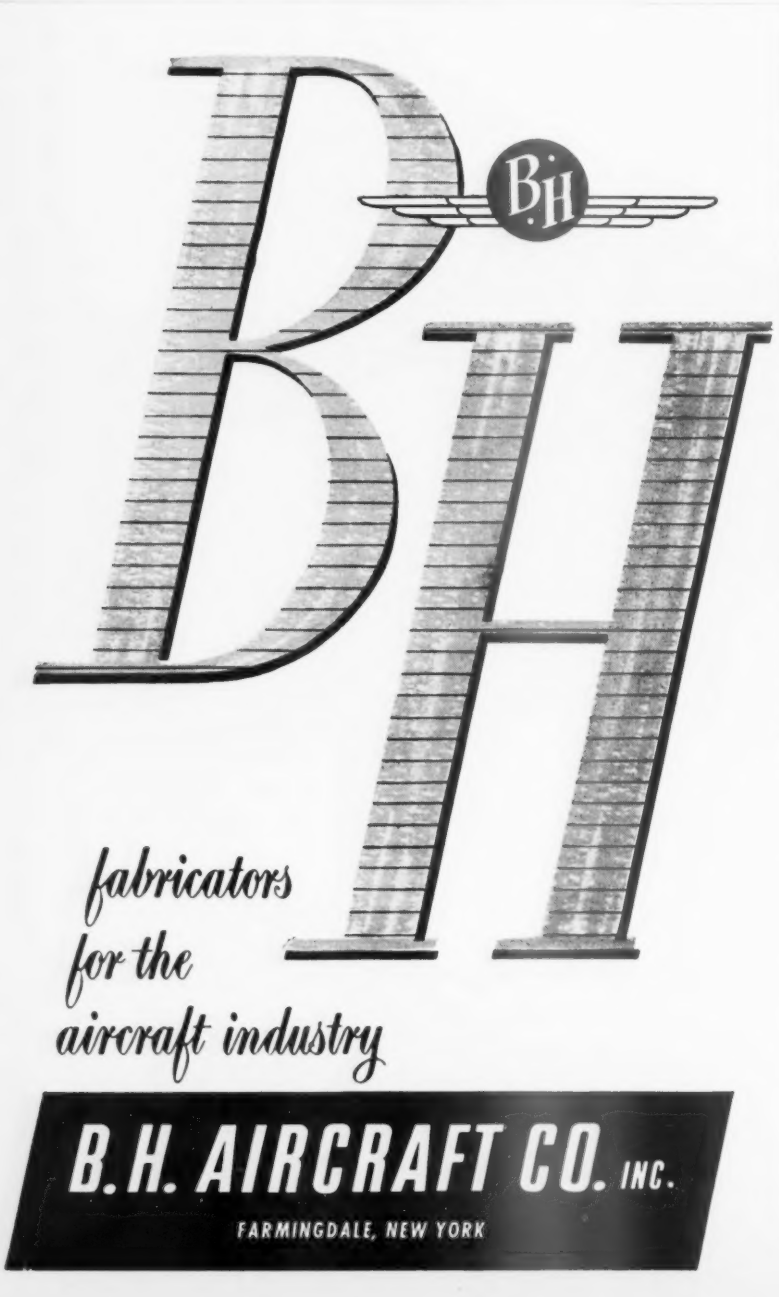
A film, *Structure of Moveable Control Surfaces*, was shown at the April 11 meeting.

A technical paper contest was held on April 26 before the following judges: F. N. M. Brown, Head, Aeronautical Engineering Department; Mr. Eikenberry, a Notre Dame faculty member; and Mr. Goddard, a Notre Dame faculty member. The papers presented and their authors include: "The Evaluation of the German V-1" by Student Member Peter Skerret; "Flying Wing Aircraft" by Student Member Joseph Lotta; and "Afterburners on Turbo-Jet Engines" by Student Member John Cassidy. The decision of the judges was withheld pending the convening of the next meeting at which time awards will be presented for the best two papers.

The University of Oklahoma

At the May 7 meeting, Chairman Marinus A. Romano introduced C. Christy Jones, District Manager, Oklahoma City Sales Office, Aluminum Company of America, who spoke on "Aluminum Alloys."

The following officers were elected during a business session: Chairman, Walter I. Meyers; Vice-Chairman, Harry N. Blosser; and Secretary-Treasurer, Raymond H. Geckler. The new officers will assume their duties at the beginning of the next school year Thirty persons were present.



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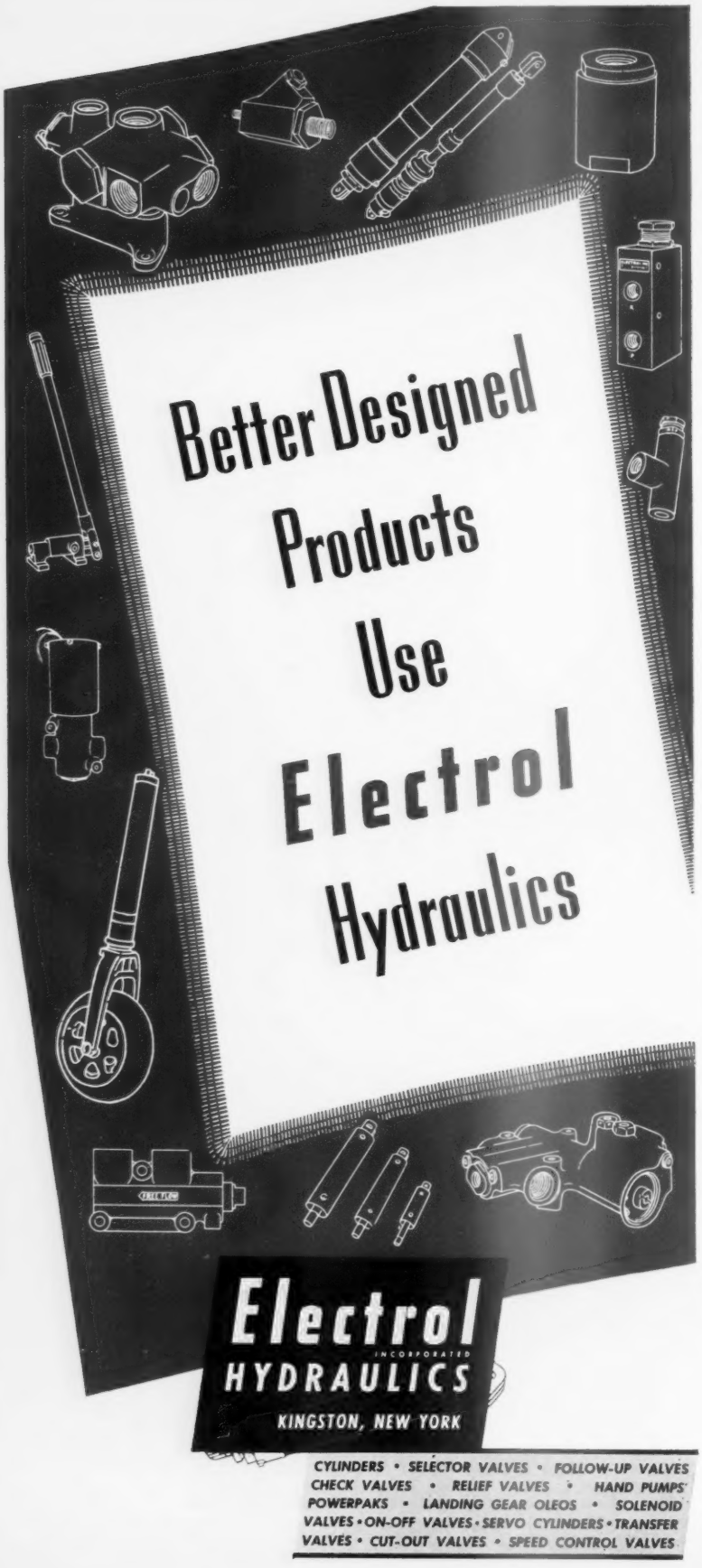

Oregon State College

Chairman Richard L. Sears opened the April 25 meeting at which an election of officers for next year was conducted. The following men were elected: Chairman, Russell A. Wilmot; Recording Secretary, Robert N. Dobbins; Corresponding Secretary, Paul D. Miller; and Treasurer, Ray A. York. Eighteen persons were present.

The Pennsylvania State College

An election of officers was held at an April meeting with the following results: Chairman, George F. Page; Vice-Chairman, Max J. Shuster; and Secretary-Treasurer, Emily A. Bell. John A. Fox was selected as the new faculty adviser.

Princeton University

The newly elected officers include: Chairman, Edwin T. Lightcap; Vice-Chairman, Marcus P. Knowlton; and Secretary-Treasurer, Roy Lanflisi.

Purdue University

On March 14, under the Chairmanship of Richard M. Clayton, Prof. Mart Fowler and Prof. Elmer Bruhn of the Schools of Air Transportation and Aeronautical Engineering presented a "Resume of Recent Purdue Field Trip." Five students assisted in this presentation. Two films, *Boeing Turbine Engine 502* and *Life Around Seattle, Washington, Area*, were shown. Fifty-five students were in attendance.

On March 19, a joint meeting was held with the Student Branch of the American Rocket Society. Dr. Maurice J. Zucrow introduced the speaker, William Bergen, Vice-President and Chief Engineer, The Glenn L. Martin Company, who gave an address on the "Effect of Guided Missiles on Aeronautical Engineering." The talk was illustrated with films from Martin on the Viking and Martin aircraft. Chairman Richard M. Clayton of the I.A.S. and J. P. Layton of the A.R.S. presided; 50 persons were present.

Dr. Hyman Serbin, Major Professor of Aerodynamics, Purdue School of Aeronautics, spoke on "Why an Airplane Doesn't Fly Upside Down," after which a film, *N.A.C.A. Laboratory Facilities*, was shown. Chairman Clayton presided at the April 12 meeting and approximately 40 persons attended.

Tri-State College

A film, *Air Power is Peace Power*, was shown at the April 26 meeting. Chairman Ben K. Gantt presided; 21 persons were present.

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1000	29,000	38,000
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University of Tulsa

Tulsa high school seniors with a penchant for aeronautical engineering were asked to attend the April 19 meeting. Dean Langenhiem, Engineering College, gave the welcome; Don Roberts, Air Materiel Command, U.S.A.F., spoke briefly on the operation of the Douglas plant and on his own affiliations with the Air Force's procurement program. Five university seniors, Messrs. Jones, Stanton, Howdell, Cunningham, and Owens, gave brief talks. A smoke tunnel was set up and operated during the intermission and at the conclusion of the program. The films shown during the evening included: *The Banshee; Jet Propulsion; The NATIV; Special Showing of Latest Aircraft; Story of the Flying Wing;* and *British Aircraft Review, 1949*. Chairman Owen Anderson presided; 61 persons were present.

West Virginia University

On April 4, Professor L. Z. Seltzer, Head, Aeronautical Engineering Department, took a group of 14 Student Members and nine guests on a guided tour of the newly erected Aerodynamics Laboratory at the Morgantown (W.Va.) Municipal Airport.

At the April 18 meeting, presided over by Chairman Sam Hill, two films, *Banshee* and *Disorientation Crashes*, were shown to the 12 persons attending.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Summerfield, Martin, Ph.D., General Editor, Aero Publication Program, and Prof. of Jet Propulsion, Aero. Dept., Princeton University.

Wegener, Peter P., Dr. rer Nat., Lecturer & Consultant, Dept. of Aero. Engineering, The Johns Hopkins University; Chief of Hyperballistics, Subdivision 111, Naval Ordnance Lab. (White Oak).

Transferred to Associate Fellow Grade

Axell, O. Goran, Civilingenjör, Technical Asst. to the Dir., The Aero. Research Institute of Sweden.

Clarkson, Christopher, Civil Air Attaché, British Embassy (Washington, D.C.).

Katzenberger, Edward F., B. of M.E., Chief Design Engineer, Sikorsky Aircraft Div., United Aircraft Corp.

LaMotte, Ralph R., M.S., Chief Engineer, Aeroproducts Div., General Motors Corp.

Pai, Shih I., Ph.D., Magna Cum Laude in Aero. & Math., Research Assoc., University of Maryland.

Piasecki, Frank N., B. of Ae.E., Chairman of the Board, Piasecki Helicopter Corp.

Voglewede, Thomas J., B.Ae.E., Head, Special Projects Branch, Flight Research Div., N.A.C.A., Langley Air Force Base.

Elected to MEMBER Grade

Chapman, Seville, Ph.D., Asst. Head, Physics Dept., Cornell Aero. Lab., Inc.

Davisson, C. Owen C., A.B., Physicist GS-12, Frankford Arsenal (Philadelphia).

Delano, James B., B.S. in M.E., Aero. Research Scientist, Langley Aero. Lab., N.A.C.A.

Dye, Edward R., C.E. (Structural Engrg.), Head, Development Div., Cornell Aero. Lab., Inc.

Evvard, John C., Ph.D. (Physics), Chief, Supersonic Propulsion Div., Lewis Flight Propulsion Lab., N.A.C.A. (Cleveland).

Gunton, Edward H., Chief Production Engineer & Asst. Secretary, Solar Aircraft Co.

Kellogg, Spencer, II, M.E., Dept. Head, Flight Instrument Engineering, Sperry Gyroscope Co. Div., The Sperry Corp.

Kolk, Franklin W., B.S.Ae.E., Mgr., Aircraft Analysis, American Airlines, Inc.

Krebs, Richard P., Ph.D., Asst. to Chief, Engine Research Div., N.A.C.A. (Cleveland).

Lawrence, William C., B.S. in Ae.E., Dir.-Development Engineering, American Airlines, Inc.

McRee, Kenneth O., B.S.M.E., Power Plant Design Engineer, McDonnell Aircraft Corp.

Moseley, Francis L.

Pasternack, Joseph M., M.S., Deputy Head, Air Branch for Science, Office of Naval Research, Dept. of the Navy.

Penne, Harold, Lt. Colonel, U.S.M.C.; Head, Propellered Engines Section, Bureau of Aeronautics, Dept. of the Navy (Washington, D.C.).

Razak, Virgil L., B.S.Ae.E., Supervisory Engineer of Wind Tunnel, University of Wichita.

Rutherford, Whitley J., Chief Engineer, Dietz Mfg. Co.

Schliemann, Julius B., S.B., Project Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Schneiter, Leslie E., B.S. in Ae.E., Aerodynamic Scientist, N.A.C.A. (Washington, D.C.).

Silver, Robert D., B.S.M.E., Mech. Engineer, North American Aviation, Inc.

Smith, Mark H., B.S., Staff Engineer, American Airlines, Inc.

Stensgaard, Conrad, Jr., B.S., Research Lab. Analyst "A," Hughes Aircraft Co.

Weaver, Virgil L., M.S., Engineer-in-Charge, Flight Test, General Electric Co. (Los Angeles).

Transferred to MEMBER Grade

Ades, Alfred E., B.Sc. in Ae.E., Asst. Dir. of Engineering, Trans-Canada Air Lines.

Bergeron, J. Paul, Asst. Engineer, Bethlehem Steel Co.

Chris, Stephen J., B. of Ae.E., Structures Design Engineer, Douglas Aircraft Co., Inc. (Santa Monica).

DeGroff, Harold M., Jr., Ph.D., Assoc. Prof., Aero. Dept., Purdue University.

Starr, David W., B.S., 1st Lt., U.S.A.F.

Westkaemper, John C., B.S.Ae.E., Aerodynamicist, Sverdrup & Parcel, Inc., assigned to the Air Force Air Engineering Development Center at Tullahoma, Tenn.

Yoder, Warren G., B.S.C.E., Civil Engineer, Civil Aeronautics Administration (Seattle).

Elected to Associate Member Grade

Ashton, Charles F., B.S. in Industrial Engrg., Sales Engineer-Aviation Representative, Ind. Products Div., Johns-Manville Sales Corp.

Lott, G. Richard, Dayton Representative, Reaction Motors, Inc.; Dayton Representative & Asst. Secretary, Marquardt Aircraft Co.

Rhonie, Aline, President & Chairman of Board of Dir., Allison Radar Corp.

Smyser, Albert E., Jr., Asst. Dir. of Public Relations, The Glenn L. Martin Co.

Thompson, John G., Lt. Comdr., FAW-1, Staff Aircraft Maintenance Officer, U.S.N.

Transferred to Associate Member Grade

Eastman, Samuel E., LL.B., Asst. Dir., External Transportation Project, University of Puerto Rico.

Elected to Technical Member Grade

Cummings, John Leo, M.Ae.E., Application Engineer, Aviation Div., General Electric Co.

Emmick, Harold E., Naval Cadet, Pre-Flight, Naval Air Station (Pensacola).

Gerhardt, Eugene, Ph.D., Design Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Kuldell, Philip D., B.S., Aero. Engineer (Aerodynamics), David Taylor Model Basin, Dept. of the Navy.

Saltarelli, Eugene A., M.S.M.E., Research Mech. Engineer, Rocket Section, Analytical Group, Bell Aircraft Corp.

Transferred to Technical Member Grade

Badalich, George M., B. of Ae.E., Engineer, Mechanical Equipment Group, Boeing Airplane Co. (Seattle).

Bagnall, Harry E., Engineering Draftsman "A," Northrop Aircraft, Inc.

Bennett, Bruce K., Naval Aviator & Sq. Engineering Officer, U.S.M.C.

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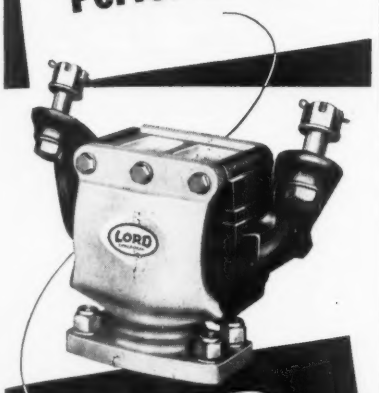

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Berger, Richard E., B.S. in A.E., Engineering Draftsman, North American Aviation, Inc.

Birks, Douglas M., Wind Tunnel Operator, Cooperative Wind Tunnel, California Institute of Technology.

Clements, Joseph R., B.S., Flight Test Engineer, Piasecki Helicopter Corp.

Cohen, Charles H., Draftsman, Sikorsky Aircraft Div., United Aircraft Corp.

Cuniberti, John S., B.S.E. in Ae.E., Aviation Cadet, U.S.A.F., Goodfellow Air Force Base.

Dahlen, Theodore E., B.Ae.E., Aero. Research Intern, N.A.C.A. (Muroc).

Drozda, Michael J., B.A., Engineering Draftsman "A," North American Aviation, Inc.

Dunbar, Reed M., Jr., B.S. in Ae.E., Jr. Project Engineer, Smith, Hinchman & Grylls, Inc.

Fite, Alfred M., Jr., B.Ae.E., Engineering Draftsman, Douglas Aircraft Co., Inc. (Long Beach).

Gebhard, David F., M.S., Administrative Engineer, Gyrodyne Co. of America, Inc.

Gossick, Lee V., M.S. in Ae.E., Major, U.S.A.F.; assigned to Directorate of Research, Div. of Background Research, Hq., Air Research & Development Command, Wright-Patterson Air Force Base.

Gregory, Paul H., Jr., M.S. in Engrg., Engineer (Aerodynamics), General Electric Co.

Gruenwald, George D., Design Draftsman, North American Aviation, Inc.

Hale, William B., B.S.Ae.E., P.F.C. & Student, U.S.A.F. Radar Mechanics School.

Hansen, Samuel G., B.E. (Aero.), Mathematician (Aerodynamics), Douglas Aircraft Co., Inc. (Santa Monica).

Herfurth, John J., B.Ae.E., Teaching Asst., Aero. Dept., University of Minnesota.

Highet, Richard D., B.S. in Ae.E., Gen. Aero. Engineer, GS-860-5, Air Research & Development Command, Wright-Patterson Air Force Base.

Hoil, Herman J., Loft Engineer, Wing Group, Republic Aviation Corp.

Kananen, Robert E., B.S.Ae.E., Draftsman Trainee-Liaison Engineering, Lockheed Aircraft Corp.

Klabosh, Charles, Engineering Asst., Performance & Req. Group, Installations Engineering Dept., Pratt & Whitney Aircraft Div., United Aircraft Corp.

Knox, Omar E., M.S.E. (Aero.), Colonel, U.S.A.F.; Chief of Operations, Aircraft Lab., Air Research & Development Command, Wright-Patterson Air Force Base.

Krueger, Lorenz J., Design Engineer, Century Engineers, Inc.

Kuhns, Ellis B., M.S.Ae.E., Stress Analyst, Consolidated Vultee Aircraft Corp. (Ft. Worth).

Lambert, Willis R., B. in Ae.E., Jr. Engineer "B," Preliminary Design Div., Engineering Dept., Boeing Airplane Co. (Seattle).

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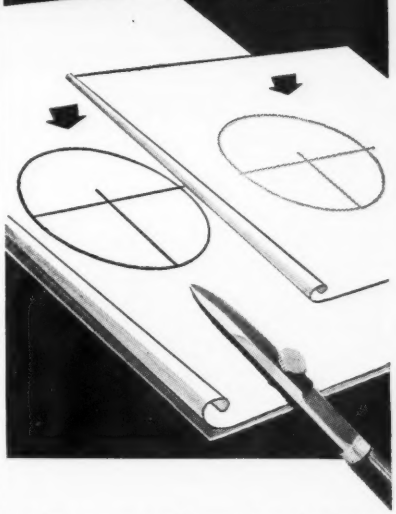

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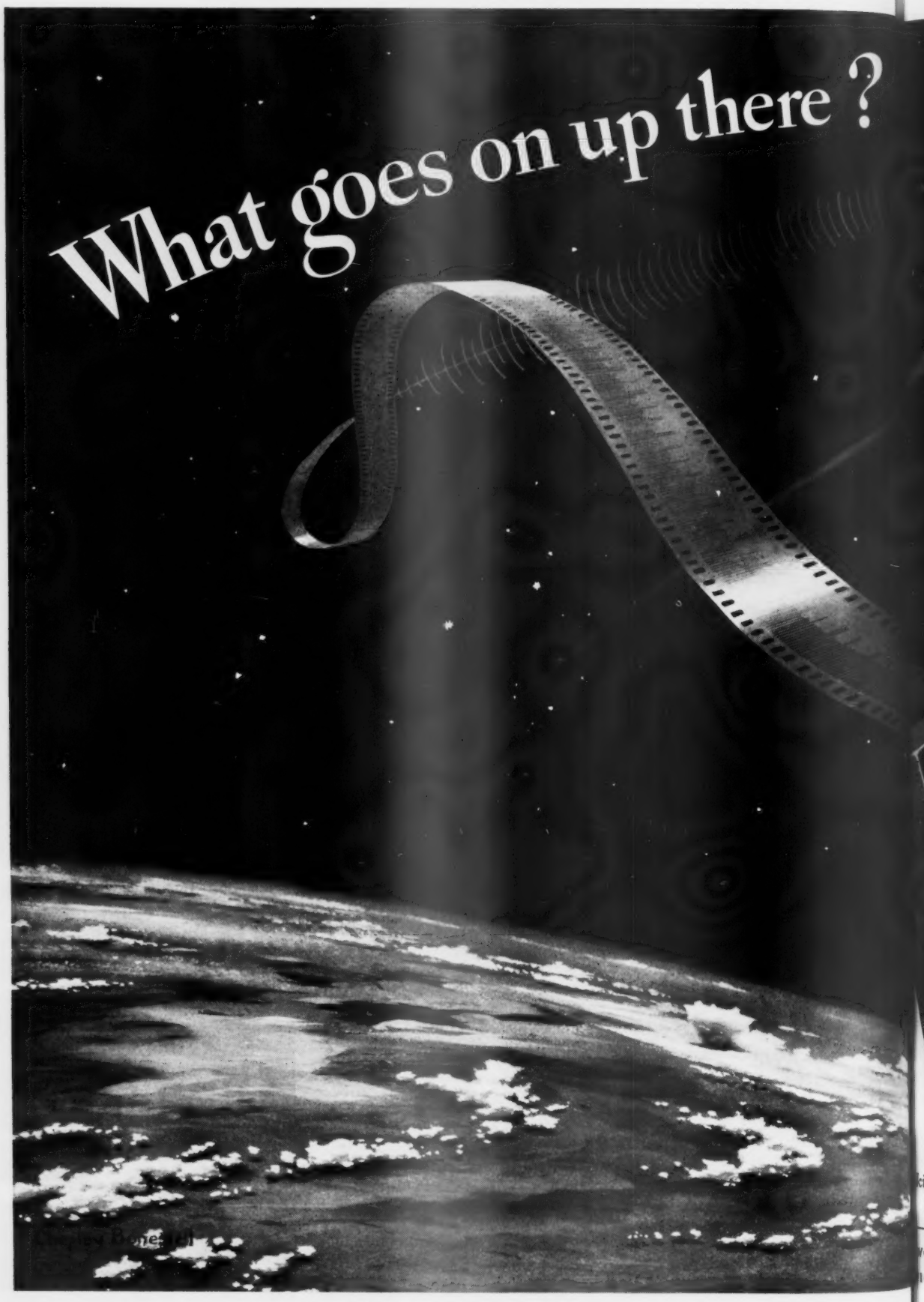
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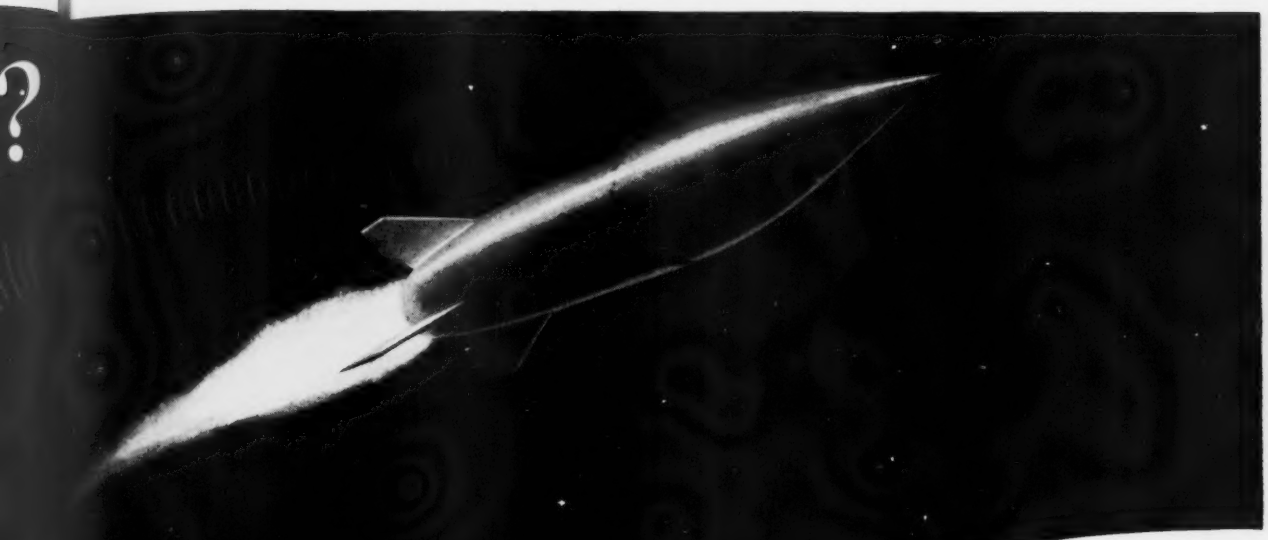

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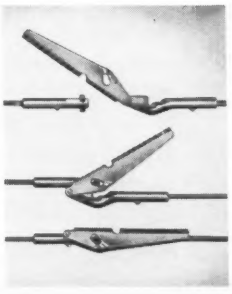

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I. PERIODICALS AND REPORTS

The abstracts are classified according to the Air Technical Index Distribution Guide. Numbers in parentheses indicate the position of the Division Headings in the numerical arrangement.

Aerodynamics (2) 64
- Boundary Layer 64
- Control Surfaces 64
- Fluid Mechanics & Aerodynamic Theory 64
- Internal Flow 66
- Performance 66
- Stability & Control 66
- Wings & Airfoils 66

Aeroelasticity 66

Air Transportation (41) 67

Airplane Design (10) 67
- Airplane Descriptions 67
- Control Systems 68
- Development Testing 68
- Ejection Seats 68
- Fuel Tanks 68
- Landing Gear 68

Airports & Airways (39) 68

Aviation Medicine (19) 68

Education & Training (38) 70

Electronics (3) 70
- Antennas 70
- Circuits & Circuit Elements 70
- Communications 73
- Components 73
- Construction Techniques 73
- Electronic Tubes 73
- Measurements & Testing 73
- Navigation Aids 75
- Transmission Lines 75
- Wave Propagation 75

Equipment
- Electrical (16) 75
- Hydraulic (20) 75

Flight Operating Problems (31)
- Cruise Control 75
- Ice Prevention & Removal 75
- Refueling in Flight 75

Flight Safety & Rescue (15) 75

Flight Testing (13) 78

Fuels & Lubricants (12) 78

Gliders (35) 78

Guided Missiles (1) 80

Instruments (9) 80

Machine Elements (14)
- Fastenings 80
- Mechanisms & Linkages 80
- Springs 80
- Transmissions, Clutches, & Drives 80

Maintenance (25) 82

Materials (8) 82
- Ceramics & Ceramals 82
- Metals & Alloys 82
- Nonmetallic Materials 84
- Protective Coatings 84
- Sandwich Materials 84

Meteorology (30) 84

Military Aviation (24) 86

Navigation (29) 86

Ordnance & Armament (22) 88

Parachutes 88

Photography 88

Power Plants
- Jet & Turbine (5) 88
- Reciprocating (6) 90

Production (36) 90

Propellers (11) 90

Reference Works (47)
- Dictionaries 90

Rotating Wing Aircraft (34) 90

Sciences, General (33)
- Mathematics 92
- Mechanics—Vibration 92
- Physics 92

Structures (7) 92

Thermodynamics (18) 95

Water-Borne Aircraft (21) 96

Wind Tunnels & Research Facilities 96

II. BOOKS REVIEWED IN THIS ISSUE

Servomechanisms and Regulating System Design, Vol. 1. H. Chestnut and R. W. Mayer 97
Reviewed by D. R. Shoults, Aro, Inc.

Laboratory Design. H. S. Coleman, Editor 97
Reviewed by Clifford C. Furnas, Cornell Aeronautical Laboratory, Inc.

High-Speed Aerodynamics. W. F. Hilton 100
Reviewed by H. W. Liepmann, California Institute of Technology

Architects of Aviation; So Away I Went; The Airmail, Jennies to Jets; Engineering and Western Civilization; L'Aviation d'Ader et des Temps Héroïques 101
Reviewed by Maurice H. Smith, I.A.S.

Book Notes 103

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Aerodynamics (2)

BOUNDARY LAYER

An Experimental Investigation of the Effect of Surface Heating on Boundary-Layer Transition on a Flat Plate in Supersonic Flow. Robert W. Higgins and Constantine C. Pappas. *U.S., N.A.C.A., Technical Note No. 2351*, April, 1951. 29 pp., illus. 14 references. Wind-tunnel tests at $M = 2.40$; free-stream temperature of −205°F.; plate temperatures of 60°, 100°, 140°, 180°, and 260°F.; and Reynolds Number range of 0.475×10^6 to 3.95×10^6.

The Effect of an Arbitrary Surface-Temperature Variation Along a Flat Plate on the Convective Heat Transfer in an Incompressible Turbulent Boundary Layer. Morris W. Rubesin. *U.S., N.A.C.A., Technical Note No. 2345*, April, 1951. 37 pp., illus. 13 references.

Readers' Forum: On the Calculation of the Rate of Heat Transfer Through a Laminar Boundary Layer. Arthur N. Tifford and John Wolansky. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 427, 428, illus. 6 references.

Approximate Calculation of Turbulent Boundary-Layer Development in Compressible Flow. Maurice Tucker. *U.S., N.A.C.A., Technical Note No. 2337*, April, 1951. 42 pp., illus. 7 references. Tables give the numerical results of parameters in the von Kármán momentum equation for turbulent boundary-layer development for use in calculating boundary-layer growth.

On Reflection of Shock Waves from Boundary Layers. H. W. Liepmann, A. Roshko, and S. Dhawan. *U.S., N.A.C.A., Technical Note No. 2334*, April, 1951. 100 pp., illus. 20 references.

Analysis of measurements of the reflection characteristics of shock waves from a flat surface with laminar and turbulent boundary layers in the GALCIT 4- by 10-in. tunnel at $M = 1.3$ to 1.5 and $R = 0.9 \times 10^6$. Measurements of the relative upstream influence of a shock for both turbulent and laminar boundary layers showed that the influence in the laminar layer extends upstream about 50 boundary-layer thicknesses, compared with five in the turbulent layer. No separation occurred in the turbulent layer.

Sideslip in a Viscous Compressible Gas. V. V. Struminskii. (*Akademiia Nauk S.S.S.R., Leningrad, Doklady*, Vol. 54, No. 9, 1946, pp. 769–772.) *U.S., N.A.C.A., Technical Memorandum No. 1276*, April, 1951. 8 pp. 2 references. Development of a theory of the three-dimensional boundary layer in a compressible gas by which the aerodynamic coefficients of a sideslipping wing can be determined.

Experimental Investigation of Localized Regions of Laminar-Boundary-Layer Separation. William J. Bursnall and Laurence K. Loftin, Jr. *U.S., N.A.C.A., Technical Note No. 2338*, April, 1951. 57 pp., illus. 15 references.

Surface pressure, boundary-layer profile, and fluctuating velocities (qualitative) were measured with a hot-wire anemometer on an N.A.C.A. 664-018 airfoil at zero incidence, and $R = 1.2$, 1.7, and 2.4×10^6.

Skin Friction in a Retarded Turbulent Boundary Layer Near Separation. B. G. Newman. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. A.73*, November, 1950. 29 pp., illus. 12 references.

Dimensional analysis of the laminar sublayer and experimental measurements of turbulent boundary layers indicate that skin friction in a turbulent boundary layer cannot be accurately calculated by the von Kármán momentum equation. A generalized equation is developed by applying a second-order approximation based on boundary-layer thickness. Two addition terms are included, one of which includes the Reynolds direct stress in the downstream direction. A formula that gives an approximation of the skin friction from the velocity profile of turbulent layers is developed by dimensional analysis.

CONTROL SURFACES

Some Theoretical Characteristics of Trapezoidal Wings in Supersonic Flow and a Comparison of Several Wing-Flap Configurations. Robert O. Piland. *U.S., N.A.C.A., Technical Note No. 2336*, April, 1951. 26 pp., illus. 13 references.

Comparison of the lift due to flap deflection and the rolling effectiveness of a rectangular wing with a half-delta tip flap (point forward) with a triangular wing that has half-delta and trailing-edge flaps and with a rectangular wing with trailing-edge flaps.

Aerodynamic Force Characteristics at High Speeds of a Full-Scale Horizontal Tail Surface Tested in the Langley 16-Foot High-Speed Tunnel. Carl F. Schueller, Gerald Hieser, and Morton Cooper. *U.S., N.A.C.A., Research Memorandum No. L7D08a*, June 9, 1947. 38 pp., illus. 2 references. Tests at $M = 0.68$; apparatus and procedure.

FLUID MECHANICS & AERODYNAMIC THEORY

Compressible Flows. James B. Kelly. *American Journal of Physics*, Vol. 19, No. 4, April, 1951, pp. 237–243, illus. 6 references. Background material.

Letters to the Editor: The Generality of Mixed Gas Flows. Max M. Munk. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, p. 524.

Investigation of the Flow Past Finite Wedges of 20 Deg. and 40 Deg. Apex Angle at Subsonic and Supersonic Speeds, Using a Mach-Zehnder Interferometer. With Appendix: Sensitivity and Accuracy of the Interference Method Applied to Pressure Measurements. E. Groth. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2321*, 1949 (May, 1946). 30 pp., illus. 6 references. British Information Services, New York. $1.40.

Tests in the high-speed tunnel A7 of the Luftfahrtforschungsanstalt, Brunswick, at $M = 0.6$–0.85 and 1.4–2.8. Pressure distributions over the wedges were evaluated by static pressure tubes and by a Mach-Zehnder interferometer. Interference photographs show the pressure and density throughout the flow field.

Two-Dimensional Subsonic Compressible Flows Past Arbitrary Bodies by the Variational Method. Chi-Teh Wang. *U.S., N.A.C.A., Technical Note No. 2326*, March, 1951. 73 pp., illus. 8 references. Computation of compressible flows past a thin curved surface and a circular cylinder, and comparison of results with exact solutions.

Method for Determining Pressure Drop of Monatomic Gases Flowing in Turbulent Motion Through Constant-Area Passages with Simultaneous Friction and Heat Addition. M. F. Valerino and R. B. Doyle. *U.S., N.A.C.A., Technical Note No. 2328*, April, 1951. 37 pp., illus., fold. charts. 10 references. Charts for determining pressure drops when heat is added at constant passage-wall temperature.

On Reflection of Shock Waves from Boundary Layers. H. W. Liepmann, A. Roshko, and S. Dhawan. *U.S., N.A.C.A., Technical Note No. 2334*, April, 1951. 100 pp., illus. 20 references.

Analysis of measurements of the reflection characteristics of shock waves from a flat surface with laminar and turbulent boundary layers in the GALCIT 4- by 10-in. tunnel at $M = 1.3$ to 1.5 and $R = 0.9 \times 10^6$. The essential structure of pulse- and step-wave shocks is examined.

Readers' Forum: The Source-Flow in Supersonic and Incompressible Theories. H. Serbin. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 431, 432. 2 references.

Transonic Flow Past a Wedge Profile with Detached Bow Wave—General Analytical Method and Final Calculated Results. Walter G. Vincenti and Cleo B. Wagoner. *U.S., N.A.C.A., Technical Note No. 2339*, April, 1951. 47 pp., illus. 8 references.

The Decay of Isotropic Temperature Fluctuations in an Isotropic Turbulence. Stanley Corrsin. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 417–423, illus. 11 references.

Analysis, in terms of correlation functions, of the problem of predicting the time rate of change of the significant statistical thermal parameters during simultaneous decay of an isotropic temperature fluctuation field and the isotropic turbulence in which it is assumed to occur.

On the Spectrum of Isotropic Temperature Fluctuations in an Isotropic Turbulence. Stanley Corrsin. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 469–473, illus. 17 references.

Development of the form of the power spectrum; comparison with the spectrum obtained with velocity fluctuations; analysis of the low, intermediate, and high wave-number ranges and determination of the "cut-off" wave number.

Letters to the Editor: Difference Between Turbulence in a Two-Dimensional Fluid and in a Three-Dimensional Fluid. T. D. Lee. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, p. 524. 3 references.

Letters to the Editor: Decay of Spectral Components in Isotropic Turbulence. Hiroshi Sato. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, p. 525, illus. 3 references.

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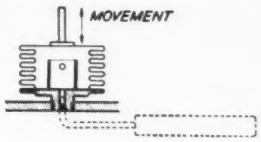

Fig. 1 Thermostatic Motor—This type of assembly is widely used in temperature regulators, etc., where a thermostatic charge is confined in the bellows and where a valve, switch, damper, etc. is to be operated in response to temperature changes.

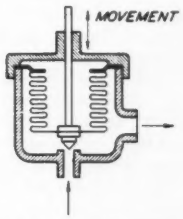

Fig. 2 Packless Construction—Illustrating packless valve construction. Same principle used to seal stem movement or adjustment in many types of apparatus.

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INTERNAL FLOW

Survey of Available Information on Internal Flow Losses Through Axial Turbomachines. Chung-Hua Wu. *U.S., N.A.C.A., Research Memorandum No. E50J13*, January 26, 1951. 34 pp., illus. 23 references.

Report of Progress on Measurements of Friction Coefficients, Recovery Factors, and Heat-Transfer Coefficients for Supersonic Flow of Air in a Pipe. Joseph Kaye, J. H. Keenan, and W. H. McAdams. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 3, April, 1951, pp. 267–277, Discussion, pp. 277–279, illus. 11 references. Measured values; Mach Number range is 1.2 to 2.5.

Method for Determining Pressure Drop of Monatomic Gases Flowing in Turbulent Motion Through Constant-Area Passages with Simultaneous Friction and Heat Addition. M. F. Valerino and R. B. Doyle. *U.S., N.A.C.A., Technical Note No. 2328*, April, 1951. 37 pp., illus., fold. charts. 10 references. Charts for determining pressure drops when heat is added at constant passage-wall temperature.

Preliminary Investigation of a New Type of Supersonic Inlet. Antonio Ferri and Louis M. Nucci. *U.S., N.A.C.A., Technical Note No. 2286*, April, 1951. 41 pp., illus. 6 references.

Analysis of a supersonic inlet with supersonic deceleration of the flow taking place entirely outside of the body. Theoretical calculations of the pressure recovery over a range of Mach Numbers and mass flow show good agreement with experiments. This configuration has a pressure recovery of 95 per cent at $M = 1.33$ and 1.52, 92 per cent at $M = 1.72$, and 86 per cent at $M = 2.10$.

Air Inlet. Robert McLarren. *Aero Digest*, Vol. 62, No. 4, April, 1951, pp. 75–85, illus. 19 references.

Problems involved in the design of air inlets for turbojet engines which provide maximum ram pressure recovery and minimum drag. Analysis of inlet types, boundary-layer bleed, and perforated throat nozzles.

Unstable Capillary Waves on Surface of Separation of Two Viscous Fluids. V. A. Borodin and IA. F. Diakin. (*Prikladnaia Matematika i Mekhanika*, Vol. 13, No. 3, 1949, pp. 267–276.) *U.S., N.A.C.A., Technical Memorandum No. 1281*, April, 1951. 19 pp., illus. 4 references. Rough approximation of the disintegration of a liquid jet; mathematical study of the appearance of droplets of varying diameters as a result of jet breakup.

PERFORMANCE

Best Climb Speed for Jet Aircraft. A. M. Jackes. *Aero Digest*, Vol. 62, No. 4, April, 1951, p. 24, illus. Graphic method of solution.

STABILITY & CONTROL

Rapid Approximate Methods of Solution to the Equations of Motion for a Steady Turn. J. R. Baxter. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. A. 74*, November, 1950. 45 pp., illus. 4 references.

Development of approximate equations for four types of turn. The method is applied to the determination of height loss by the Twin Jet Stork radio-controlled model in pure aileron turns of various bank angles for several values of the initial C_L.

A Least Squares Curve Fitting Method with Applications to the Calculation of Stability Coefficients from Transient-Response Data. Marvin Shinbrot. *U.S., N.A.C.A., Technical Note No. 2341*, April, 1951. 52 pp., illus. 5 references.

Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method. James B. Rea. (*Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950.) *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 375–397, illus. 17 references.

A Survey of Methods for Determining Stability Parameters of an Airplane from Dynamic Flight Measurements. Harry Greenberg. *U.S., N.A.C.A., Technical Note No. 2340*, April, 1951. 49 pp., illus. 7 references. Methods of determining transfer-function coefficients.

WINGS & AIRFOILS

Sideslip in a Viscous Compressible Gas. V. V. Struminskii. (*Akademiia Nauk S.S.S.R., Leningrad, Doklady*, Vol. 54, No. 9, 1946, pp. 769–772.) *U.S., N.A.C.A., Technical Memorandum No. 1276*, April, 1951. 8 pp. 2 references. Development of a theory of the three-dimensional boundary layer in a compressible gas by which the aerodynamic coefficients of a sideslipping wing can be determined.

Mapping Functions of the N.A.C.A. Airfoils into the Unit Circle. Isao Imai, Ikuo Kaji, and Kwai Umeda. (*Hokkaidō University, Faculty of Science, Journal*, Series 2, Vol. 3, No. 8, 1950, pp. 265–304.) *Numerical Computation Bureau, Tokyo, Report*, February, 1950. 40 pp., illus., tables. 4 references. Numerical calculation of the mapping functions by setting up the boundary conditions and using Fourier techniques.

Negative Camber Airfoils for Transonic Flight. Thomas B. Woersching. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 361–368, illus. 8 references.

Potentialities of airfoils with "W" camber (the camber of the forward 75 to 80 per cent of the chord is negative; at 85 per cent chord the camber is positive and then is negative aft to the trailing edge) in transonic flight; analysis of airfoil characteristics.

Method for Calculating Downwash Field Due to Lifting Surfaces at Subsonic and Supersonic Speeds. Sidney M. Harmon. *U.S., N.A.C.A., Technical Note No. 2344*, April, 1951. 30 pp., illus. 13 references. Source singularities, whose distribution is specified by the loading on the wing, are used to obtain the linearized downwash field.

Flight Measurements of Profile Drag at High Speeds. W. A. Mair. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2555*, 1951 (July, 1942). 11 pp., illus. 5 references. British Information Services, New York. $0.65. The profile drag of an 18 per cent wing section at speeds up to $M = 0.7$ by a pitot-traverse method.

Supersonic Lift and Pitching Moment of Thin Sweptback Tapered Wings Produced by Constant Vertical Acceleration; Subsonic Leading Edges and Supersonic Trailing Edges. Frank S. Malvestuto, Jr., and Dorothy M. Hoover. *U.S., N.A.C.A., Technical Note No. 2315*, March, 1951. 44 pp., illus. 14 references.

A Study of Airfoil Pressure Distribution at Supersonic Speeds. M. J. Thompson. *Texas, University, Defense Research Laboratory, Report No. CF-821, UT/DRL-142*, November 15, 1947. 53 pp., illus., fold. charts. 11 references. Calculation of pressure distributions on two-dimensional airfoils by means of the linear and second-order perturbation theories; comparison with test results at $M = 2.13$.

Readers' Forum: On the Nonexistence of Subsonic Conical Flows. Theodore R. Goodman. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, p. 427. 1 reference. Conical flows are merely mathematical tools for solving nonconical flow problems and have no significance in themselves.

A Plan-Form Parameter for Correlating Certain Aerodynamic Characteristics of Swept Wings. Franklin W. Diederich. *U.S., N.A.C.A., Technical Note No. 2335*, April, 1951. 17 pp., illus. 15 references.

Derivation of approximate expressions for the lift-curve slope and of the coefficient of damping in roll of swept wings in compressible subsonic flow. A plan-form parameter is developed which is a function of the aspect ratio, the sweep, and the section lift-curve slope.

Some Theoretical Characteristics of Trapezoidal Wings in Supersonic Flow and a Comparison of Several Wing-Flap Configurations. Robert O. Piland. *U.S., N.A.C.A., Technical Note No. 2336*, April, 1951. 26 pp., illus. 13 references.

Derivation, by means of the linearized theory, of the lift and pitching moment due to angle of attack and the lateral force and yawing moment due to rolling for a trapezoidal wing with raked-out tips. The analysis is extended to the reverse wing (raked-in tips).

Resistance of a Delta Wing in a Supersonic Flow. E. A. Karpovich and F. I. Frankl. (*Prikladnaia Matematika i Mekhanika*, Moscow, Vol. 11, No. 4, 1947, pp. 495, 496.) *U.S., N.A.C.A., Technical Memorandum No. 1283*, April, 1951. 6 pp., illus. 3 references.

Presentation of a formula for computing the resistance of a delta wing at small incidence in supersonic flow. The momentum theory is applied to the volume of air within the Mach cone enclosing the leading edges, and the suction force is separated out.

Aeroelasticity

Transient Aerodynamic Behavior of an Airfoil Due to Different Arbitrary Modes of Nonstationary Motions in Supersonic Flow.

Chieh-Chien Chang. *U.S., N.A.C.A., Technical Note No. 2333*, April, 1951. 65 pp., illus. 11 references.

The behavior of all the degrees of freedom is expressed in terms of a function $C(\beta, M)$ where C is the wing chord, M is the Mach number, and β is related to the frequency of oscillation. This function, derived in an earlier work of the author, enables the harmonically oscillating airfoil with different modes or degrees of freedom to be analyzed for its complete history, assuming that the motion starts abruptly from rest. The transient behavior of an airfoil is investigated by means of the Fourier integral method. The effect of a control surface attached to the airfoil and deflected on a prescribed time schedule is evaluated from the result for the main wing.

Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method. James B. Rea. (*Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950.) *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1950, pp. 375–397, illus. 17 references.

Flutter of Control Surface Tabs. G. A. Naylor. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2606*, 1951 (April, 1942). 12 pp., illus. 4 references. British Information Services, New York. $0.65.

High-frequency oscillations (dither) in flight involves bending of the control-surface structure supporting the tab. Binary-flutter calculations were made for the rotation of the tab about its hinge, coupled with translation of the tab. The calculations give minimum flutter speeds for trimming and balancing tabs.

Air Transportation (41)

How CAA Forecasts Air Traffic Potential. Frederick B. Lee. *SAE Journal*, Vol. 59, No. 4, April, 1951, pp. 44, 45. (Based on a paper: Air Transportation and What Is the General Future.)

Air Cargo Ground Handling Proposals. *Douglas Aircraft Company, Inc.*, 1951. 13 pp., illus. Illustrations show suggested airport and aircraft installations for efficient handling.

Some Economic Factors in Air Transport Operation (with Special Emphasis on Short-Haul Services). Peter G. Masefield. (9th Brancker Memorial Lecture, February 12, 1951.) *Institute of Transport, Journal*, Vol. 24, No. 3, March, 1951, pp. 79–108, illus. 8 references. Historical background of British civil air transport; operating progress; traffic and financial statistics; budgeting; cost analysis; controls.

Airplane Design (10)

Flight Experience with Turbine Propeller Powered Aircraft. R. C. Loomis and E. D. Shannon. *S.A.E., National Aeronautic Meeting (Spring), New York, April 16–19, 1951, Preprint No. 616.* 13 pp., illus. 7 references. Conclusions concerning the performance of turboprop aircraft which were drawn from flight experience with the Convair 240 and the XP5Y-1.

The Case for Factors of Safety of 1.5 Instead of 2.0, with Special Reference to the Flight Envelope. P. E. Montagnon. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2578*, 1951 (January, 1944). 6 pp., illus. 3 references. British Information Services, New York. $0.40.

Desirability of using a factor of safety of 1.5 in all design strength requirements. Using 1.5 would make the basic condition the same as the severest conditions encountered in actual flight and make the basic condition suitable for structural testing. With 1.5 rather than 2.0, under the operational limits expected, the structure is not quite proof-loaded. The ideal flight envelope is developed, and a practical example shows the advantages of the lower safety factor.

Naval-Aircraft Design; General Principles: Double Power Units; Background of the Fairey 17 and Double Mamba. D. L. Hollis Williams. *Flight*, Vol. 59, No. 2202, April 6, 1951, pp. 399–403, illus. (Based on an R.Ae.S. lecture, March 29, 1951: Some Aspects of Modern Naval Aircraft Design.)

Naval Aircraft Design. D. L. Hollis Williams. *The Aeroplane*, Vol. 80, Nos. 2072, 2073, April 6, 13, 1951, pp. 407–409; Discussion, p. 431, illus. (Based on an R.Ae.S. lecture, March 29, 1951: Some Aspects of Modern Naval Aircraft Design.)

AIRPLANE DESCRIPTIONS

1951 Jet Fighters. *Interavia*, Vol. 6, No. 2, February, 1951, pp. 79–86, illus. 1 reference. A review of the world's jet fighter

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aircraft, giving photographs, specifications, and probable armament. Complete specifications, where available, are tabulated.

Russian Aircraft Review. F. G. Swanborough. *The Aeroplane*, Vol. 80, No. 2070, March 23, 1951, pp. 349–353, illus. Current aircraft are listed according to the designers' names. Specifications of service aircraft are tabulated.

Avro (Canada) C.102 Jetliner Four-Engined Turbojet Transport, Canada. James C. Floyd. *SAE Quarterly Transactions*, Vol. 5, No. 2, April, 1951, pp. 217–235, 272, illus.

Brief summary of the design and general problems encountered in the development of the first prototype up to flight-test stages in 1949, including an analysis of direct and indirect operating costs.

de Havilland DHA-3 Drover Three-Engined Feeder Transport, Australia. Stanley Brogden. *Aviation Age*, Vol. 15, No. 4, April, 1951, pp. 34, 35, illus.

English Electric Canberra B-2 Twin-Engined Turbojet Bomber, England. *Aeronautics*, Vol. 24, No. 3, April, 1951, pp. 40–42, illus.

Fokker S.11 Single-Engined Primary Military Trainer and S.11 Single-Engined Turbojet Military Trainer, Netherlands (Aviation Design Progress). Randolph Hawthorne. *Aviation Age*, Vol. 15, No. 4, April, 1951, pp. 26, 27, cutaway drawings.

Gloster Meteor 8 Twin-Engined Turbojet Interceptor, England. *Flight*, Vol. 59, No. 2201, March 30, 1951, pp. 358, 359, illus., cutaway drawings.

Lockheed Model XR60-1 Constitution 4-Engined Transport (Lockheed Constitution Development Story). W. W. Hawkins, Jr., and R. L. Thoren. *Lockheed Aircraft Corp.*, December, 1950. 54 pp., illus.

Design development: general specifications; layout drawings; interior and crew arrangements; aerodynamic development: wing development stability and control studies; drag evaluation; power plant and systems developments; basic structural design; design of the landing gear and wing flap systems; production planning; flight development and testing.

North American F-86E (Canadair) Single-Engined Turbojet Interceptor, Canada. *Canadian Aviation*, Vol. 24, No. 4, April, 1951, pp. 22–26, illus. Production equipment and methods.

SAAB Scandia Twin-Engined Transport Airplane, Sweden. Stig Ekeborg. *Saab Sonics*, No. 13, January–March, 1951, pp. 8, 9, 17, illus. Operating costs.

S.N.C.A.S.E. SE-2410 Grognard Twin-Engined Turbojet Ground-Attack Airplane, France. *Aviation Week*, Vol. 54, No. 16, April 16, 1951, pp. 36–38, illus.

CONTROL SYSTEMS

Chain You Can't Hook Up Wrong. *Aviation Week*, Vol. 54, No. 16, April 16, 1951, p. 45, illus. A new roller chain and sprocket arrangement, developed by Renold and Coventry Chain Co., Ltd., is coupled with a guard that eliminates the possibility of incorrect hookup.

DEVELOPMENT TESTING

Mercator Drop Test Technique. Kenneth D. Engle. *Aero Digest*, Vol. 62, No. 4, April, 1951, pp. 30, 31, 88–90, illus.

Test program and setup for reproducing landing conditions of the Martin P4M-1 Mercator. Wing lift in landing is simulated by an arrangement of hydraulic-pneumatic snubbers; wheels are spun at speeds up to the equivalent of 130 m.p.h. ground speed by low-pressure air turbines. Recording accelerometers, strain gages, and potentiometers are set up in the plane and on the beams that support the landing platform.

EJECTION SEATS

Problems of Pilot Ejections. J. Martin. *The Aeroplane*, Vol. 80, No. 2071, March 30, 1951, pp. 378, 379, illus. (Summary of an R.Ae.S. Lecture, March 6, 1951.) Design aspects.

FUEL TANKS

Development of Sabre Combat Tanks. Robert Sohn. *Aero Digest*, Vol. 62, No. 4, April, 1951, pp. 22, 23, 56, 58, 60, illus. Design development and flight testing of external fuel tanks for combat use.

LANDING GEAR

Aircraft Wheels and Brakes. J. Wright. *The Aeroplane*, Vol. 80, No. 2071, March 30, 1951, pp. 388, 389, illus. (Summary of an R.Ae.S. Lecture.) Aircraft undercarriage design satisfying safety and weight requirements; tire loadings and tests.

The Semi-Articulated Multi-Wheel Bogie Undercarriage. P. Person and J. Perdue. *Aircraft Engineering*, Vol. 23, No. 266, April, 1951, pp. 104–106, illus.

Operation of a multiwheel bogie that is mounted on a telescopic leg fitted with a shock absorber. A lightly sprung dashpot-jack unit holds the gear in position. Position and action of the gear in taxiing and braking are explained, and the action is illustrated by several numerical examples.

Airports & Airways (39)

New Hangar Comes Apart in the Middle. *Aviation Week*, Vol. 54, No. 15, April 9, 1951, p. 37, illus.

The Mitchell Mobilhangar is built in two sections that are brought together to enclose the aircraft after it has taxied into position on its own power. The hangar is demountable and mobile. The unit is 172 ft. wide and 100 ft. long and will cost less than $100,000.

Recent Developments in Visual Low-Approach and Landing Aids for Aircraft. Maurice A. Garbell. (*Illuminating Engineering, Society, Aviation Section, Annual Conference, Indianapolis, October 25, 1949.*) *Garbell Research Foundation, Garbell Aeronautical Series No. 1*, 1951. 19 pp., illus. 11 references. $0.60. Evaluation of the Slope-Line and Calvert Transverse-Bar approach-light systems by actual flight-test procedures; test techniques.

A New System of Surface Markings for Aircraft Runways. Maurice A. Garbell. *Garbell Research Foundation, Garbell Aeronautical Series No. 2*, 1951. 7 pp., illus. 1 reference. $0.25. Design of a runway-marking system that provides directional, roll or bank, elevation, transverse, and longitudinal guidance and provides positive identification of the runway.

Aviation Medicine (19)

The Latency of Hypoxia on Exposure to Altitude Above 50,000 Feet. U. C. Luft, H. G. Clamann, and E. Opitz. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 117–122, 136, illus. 8 references.

High Altitude-High Velocity Flying with Special Reference to the Human Factors. III—Bare Skin Hazard from Frostbite in Escape from Aircraft. A. P. Webster and H. A. Smedal. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 89–99, illus. 8 references.

Comparative Experimental Studies of the Effects of Simulated High Altitudes on Five Vertebrates. Bernard Metz. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 132–136. 30 references.

Voluntary Tolerance of the Human to Impact Accelerations of the Head. Charles F. Lombard, Smith W. Ames, Herman P. Roth, and Sheldon Rosenfeld. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 109–116, illus. 3 references.

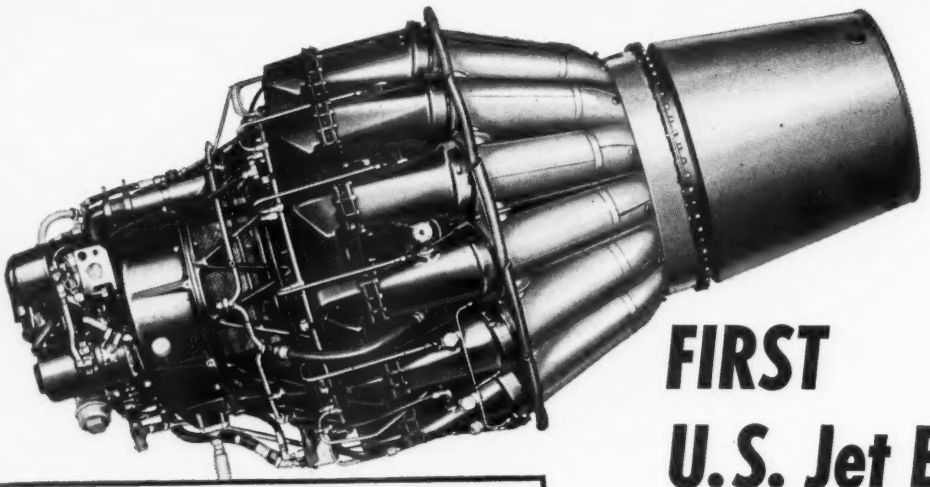
Spatial Disorientation in Flight. Ashton Graybiel. **Discussion.** Walter A. Carlson. *Military Surgeon*, Vol. 108, No. 4, April, 1951, pp. 287–294, illus. 14 references. Review of the problem of spatial disorientation based on the specific sensory experiences involved.

The Human Time Factor in Flight. II—Chain of Latencies in Vision. H. Strughold. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 100–108, illus. 31 references.

Pilot Candidate Selection Research Project. Verne W. Lyon. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 152–155.

A Subsequent Report on Dramamine; The Prophylactic and Therapeutic Control of Motion Sickness and Vestibular Disturbances. Leslie N. Gay. *Military Surgeon*, Vol. 108, No. 4, April, 1951, pp. 324–331. 18 references.

Comparison of Scopolamine Hydrobromide and Dramamine in the Treatment and Prevention of Airsickness. John D. Boland and Alan D. Grinstad. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 137–145. 5 references.



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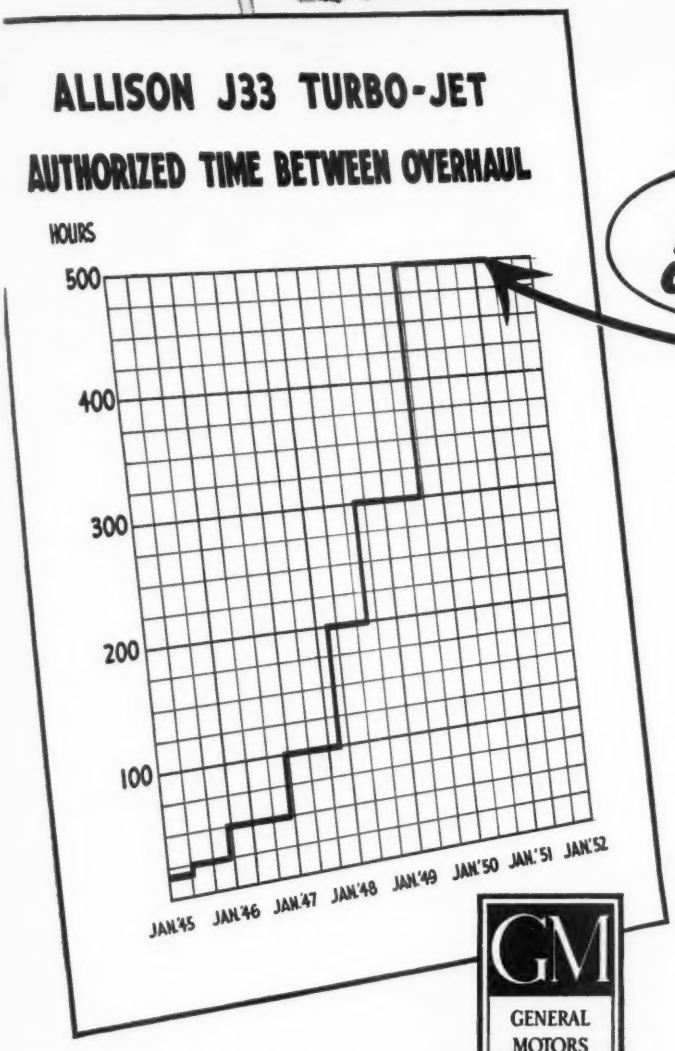

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A Study of Bailouts for a Five-Year Period in the U.S. Navy. Walton L. Jones. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 123–131, 155.

A Pick-Up and Amplifier for the Ballistocardiograph. Clarence V. Pestel and John P. Marbarger. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 156.

Education & Training (38)

Instruction for the Preparation of Technical Instruction Manuals by Personnel of the Engineering Divisions of the Industrial Department. J. C. McGinley. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 754*, January, 1951. 11 pp. 1 reference.

Instructions for the Preparation of Engineering Reports by Personnel of the Engineering Divisions of the Industrial Department. J. C. Boyle. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 755*, January, 1951. 7 pp. 3 references.

Electronics (3)

Electronic Research in the Emergency Program. W. C. White. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 82–85, illus. 2 references.

Radio Progress During 1950. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 359–396. 1,084 references. Summary of U.S. radio-electronic developments with references (U.S. and foreign) listed in the text. Information is grouped under 19 broad headings.

Standards on Abbreviations of Radio-Electronic Terms, 1951 (Standard No. 51 IRE 21 S1). *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 397–400.

Electronics Simplified. Esther Forbes. *Aero Digest*, Vol. 62, No. 4, April, 1951, pp. 19, 20, 48, 49, illus.

Single-unit design, containing complete subcircuits in plug-in packages, simplifies replacement, conserves space, and speeds production of complex electronic equipment at Servomechanisms, Inc.

On Record; Hawker's Adopt a Voice-on-Wire Recorder (Wirek, Ltd.) to Replace the Test-Pilot's Knee-Pad. *Flight*, Vol. 59, No. 2203, April 13, 1951, p. 422, illus.

ANTENNAS

Photo Radiation Patterns. Gerhart W. Goebel. *Electronics*, Vol. 24, No. 5, May, 1951, p. 89, illus.

Synthesis of two-dimensional patterns of two or more radiators of the same frequency and polarization. A bull's-eye target representing the wave image is reproduced photographically and another target, representing the pattern of another radiator, is superimposed on the original.

The Effect of a Grounded Slab on the Radiation from a Line Source. C. T. Tai. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 405–414, illus. 8 references.

The Theory of Parallel-Plate Media for Microwave Lenses. E. A. N. Whitehead. (*I.E.E., Radio Section, Paper No. 1093.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 52, March, 1951, pp. 133–140, illus. 1 reference.

Diffraction Pattern of Microwaves Near Rods. C. L. Andrews. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 465–468, illus. 4 references.

CIRCUITS & CIRCUIT ELEMENTS

Sensing Systems. John D. Goodell. *Radio & Television News*, Vol. 45, No. 4 (*Radio-Electronic Engineering*, Vol. 16, No. 4), April, 1951, pp. 3A–5A, illus. Different types of bridges for translating mechanical motion into an electrical signal; the mechanical motions that actuate the bridges.

Multiple-Channel D-C Amplifier. Leonard Goldberg. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 188, 190, 193, 194, 196, 198, 200, illus.

A type of amplifier for d.c. analog computers which will perform any number of operations simultaneously; design, uses, advantages, and disadvantages. Basic design may follow conventional single-channel-amplifier principles, provided the circuit has a differential first stage.

Maximum Output from a Resistance-Coupled Triode Voltage Amplifier. Joseph M. Diamond. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 433, 434, illus.

An Electronic Instrument for the Measurement of the Damping Capacity of Materials. A. D. N. Smith. *Journal of Scientific Instruments*, Vol. 28, No. 4, April, 1951, pp. 106–109, illus. 4 references.

An instrument for measuring the rate of decay of any vibration that is exponential and in the frequency range of 50–10,000 cycles per sec. The vibrations are detected by an electrical pickup. A circuit that transmits two timed pulses to an electronic timing unit measures the time for the amplitude of vibration to decrease to half its value during decay. The maximum error in the measured time is $\pm^1/_2$ the period of vibration. A circuit diagram gives the arrangement and values of the components.

A New Centimeter-Wave Discriminator and Its Application to a Frequency-Stabilized Oscillator. K. C. Johnson. (*I.E.E., Radio Section, Paper No. 1096.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 52, March, 1951, pp. 77–80, illus. 2 references.

The discriminator uses the change of phase of a single resonant cavity to detect changes in frequency. The discriminator is applied to stabilize the frequency of a reflex-klystron oscillator. Errors in the oscillation frequency, which are detected by the discriminator, alter the reflector voltage on the oscillator to reduce the error. The apparatus can serve as a sensitive extensometer.

Synchronized Electronic Switch. Joseph F. Dundovic and Tenny Lode. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 136, 138, 156, 160, illus. 1 reference.

A square-wave generator (Eccles-Jordan flip-flop circuit) is used whose frequency is exactly one-half the sweep frequency of the oscilloscope. Sharp trigger pulses of constant amplitude over the frequency range of the sweep oscillator are obtained with a Schmitt circuit.

An Improved Electronic Dew-Point Hygrometer. Earl W. Barrett and Lee R. Herndon, Jr. *Journal of Meteorology*, Vol. 8, No. 1, February, 1951, pp. 41–51, illus. 6 references.

Capacitive Slip Ring for Instrumentation. F. P. Fischer and C. H. Coogan, Jr. *Electronics*, Vol. 24, No. 1, January, 1951, pp. 84, 85, illus. 2 references. Thermistor elements are connected to an r.f. bridge by capacitor rings for temperature measurements on rotors at speeds greater than 20,000 r.p.m.

Operation of Electrodynamometer Instruments Through Amplifiers. W. G. Hoover. *Electronics*, Vol. 24, No. 1, January, 1951, pp. 122, 159, 160, 162, illus. Circuit diagram, operation, and sensitivity of a direct-coupled power amplifier.

Automatic Calibration of Radiosonde Baroswitches. Stephen S. Haynes. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 126–129, illus.

Paper is fed through the recorder at a speed proportional to the changes in test-chamber pressure, which is measured by an automatic barometer. A servomotor driving a precision lead screw moves a phototube to follow the top of the mercury column, and the column position is transmitted to chart-printing recorders. The complete calibration equipment gives 150-point calibration charts for 16 pressure switches simultaneously in 8 min.

Adjacent-Channel Rejection Receiver. Henry Magnuski. *Electronics*, Vol. 24, No. 1, January, 1951, pp. 100–104, illus.

A receiver that minimizes intermodulation and desensitizing of adjacent-channel frequencies uses a passive bandpass filter. The filter can assure at least a 100-db. rejection at the edge of an adjacent channel. Graphs show the performance of this receiver.

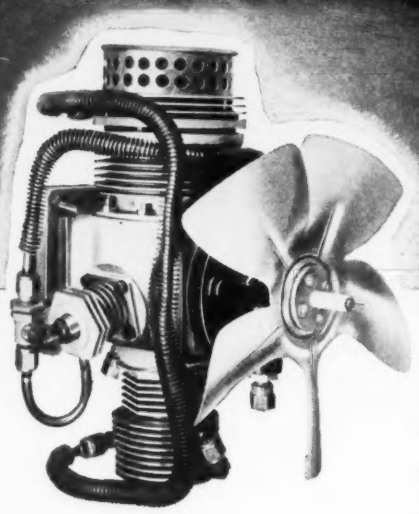
Wide-Range Resonators for VHF and UHF. G. Franklin Montgomery and Peter G. Sulzer. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 200, 202, 204, 206, illus. 2 references. Characteristics of resonators for use at frequencies between 50 and 550 megacycles.

Simplified Q Multiplier. H. E. Harris. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 130–132, 134, illus. 4 references.

Design of a circuit, based on the cathode follower, which utilizes positive feedback to obtain a negative resistance characteristic. Connection of this circuit in parallel with a tuned circuit gives an increase in Q.

The Synthesis of RC Networks to Have Prescribed Transfer Functions. H. J. Orchard. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 428–432, illus. 3 references.

Design of a network in the form of a lattice which can provide any arbitrary transfer function handled by an RC system. A



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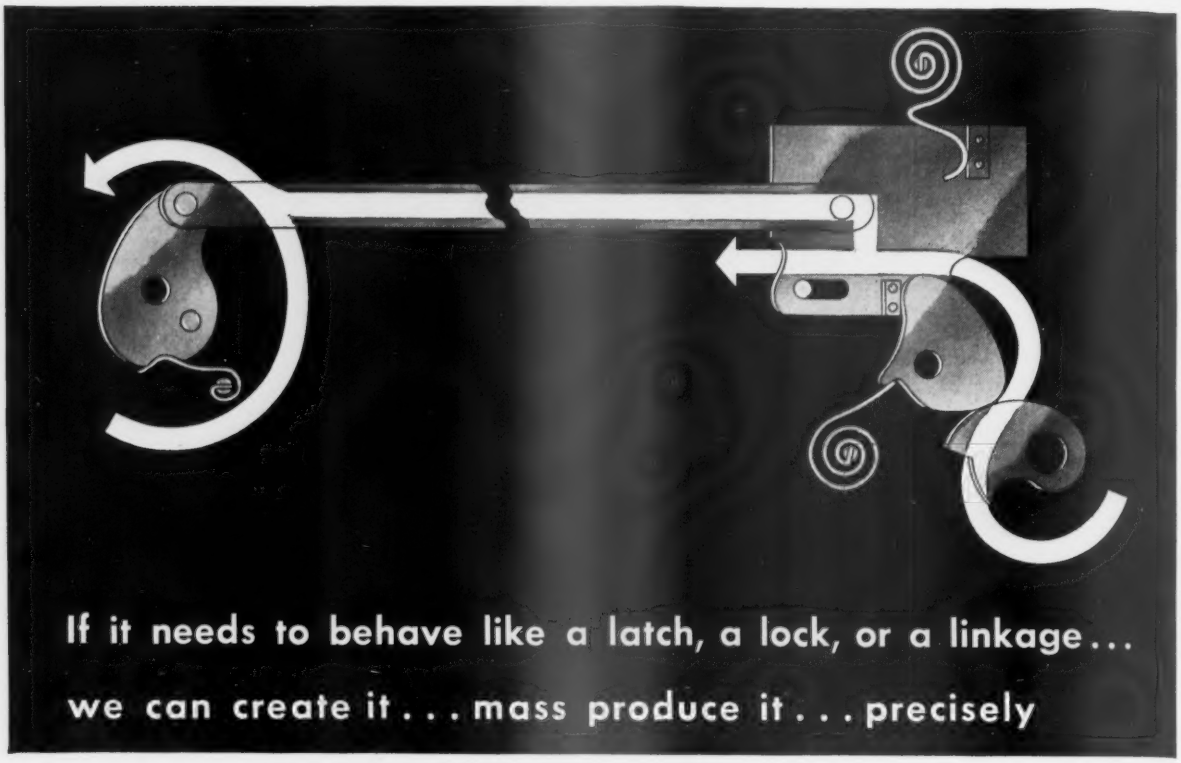

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practical synthesis procedure is presented and is illustrated by a numerical example.

A Low-Frequency Electronic Integrator. B. H. Harrison. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 725*, February, 1951. 29 pp., illus., fold. charts. 6 references. Design, operation, and maintenance of Type 63A D.C. Electronic Integrator developed for acquiring velocity data from measurements of acceleration.

Visual Presentation of Binary Numbers. E. H. Lenaerts. *Electronic Engineering*, Vol. 23, No. 278, April, 1951, pp. 140, 141, illus. 2 references.

In the storage system of an electronic digital computer, the pulse (1) appears as a short vertical line on a cathode-ray-tube screen, and the absence of pulses (0) appears as a spot of light. A switching system displays the contents of any of the storage lines.

An Investigation of Intermittent Heating for Aircraft Ice Protection. Frederick Weiner. *California, University, Los Angeles, M.S. in Engineering Thesis*, December, 1950. 79 pp., illus. 18 references. Linear and nonlinear networks for the Thermal Analyzer, an electric analog computer for solving heat-transfer problems of propeller blades during icing.

Static Magnetic Memory for Low-Cost Computers. Marshall Kincaid, John M. Alden, and Robert B. Hanna. *Electronics*, Vol. 24, No. 1, January, 1951, pp. 108–111, illus. 3 references.

The Static Magnetic Memory provides permanent information storage without mechanical mechanisms. The core material, Deltamax, has a rectangular hysteresis loop, which provides information-handling rate ranges from 0 to 30,000 pulses per sec. No power is required for pulse storage.

Resistance Network Analogue for Solving Vibration Problems. Walter W. Soroka. *Product Engineering*, Vol. 22, No. 4, April, 1951, pp. 103–105, illus. Circuit and network design; theory; accuracy.

Automatic Frequency Control; A Circuit for Controlling the Clock Pulse Frequency in Digital Calculators. J. M. M. Pinkerton. *Electronic Engineering*, Vol. 23, No. 278, April, 1951, pp. 142, 143, illus. 2 references.

An Analog Computer for Flame Gas Composition. William S. McEwan and Sol Skolnik. *Review of Scientific Instruments*, Vol. 22, No. 3, March, 1951, pp. 125–132, illus. 3 references.

The analog computer is designed on the principle that the reaction constant equilibria can be represented by the Wheatstone bridge relationship, $R_1/R_2 = R_3/R_4$. Three arms of the bridge are proportional to the partial molecular pressures, and the fourth arm is proportional to the equilibrium constant. Arrangement and equations of the component circuits and a wiring diagram of the computer are given.

COMMUNICATIONS

Radio Communications for Civil Aviation. Peter Sinclair. *Aeronautics*, Vol. 24, No. 3, April, 1951, pp. 26–30, illus. Survey; typical installations.

The M.C.A.-V.H.F. Area Coverage Network Audio Frequency Distribution. J. L. French. *Electronic Engineering*, Vol. 23, No. 278, April, 1951, pp. 146–148, illus.

The M.C.A.-V.H.F. Area Coverage Network Provision of Transmitting Station Equipment. D. H. C. Scholes. *Electronic Engineering*, Vol. 23, No. 278, April, 1951, pp. 148–150, illus.

Correlation Functions and Spectra of Phase- and Delay-Modulated Signals. L. A. Zadeh. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 425–428, illus. 11 references.

COMPONENTS

Factors Affecting the Life of Impregnated-Paper Capacitors. H. F. Church. (*I.E.E., Paper No. 1076.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 52, March, 1951, pp. 113–122, illus. 16 references.

Measurement of the Electrical Behaviour of Piezo-Electric Resonators. C. F. Floyd and R. L. Corke. (*I.E.E., Radio Section, Paper No. 1097.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 52, March, 1951, pp. 123–132, illus. 4 references.

Methods of Increasing the Power Rating of Vibratory Converters. K. H. Dixey and C. V. Wilman. (*I.E.E., Radio Section, Paper No. 1047.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 52, March, 1951, pp. 105–111, illus. 10 references.

Equivalent Circuit for the Multi-Winding Transformer. E. Uhlmann. *ASEA Journal*, Vol. 24, Nos. 1-2, January-February, 1951, pp. 17–22, illus. 3 references.

The Characteristics and Some Applications of Varistors. Frank R. Stansel. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 342–358, illus. 28 references.

Ferromagnetic Ceramics. Harold A. Goldsmith. *Product Engineering*, Vol. 22, No. 4, April, 1951, pp. 97–102, illus.

Characteristics of ferrites which make them suitable for core materials. Tables and graphs show the favorable performance of ferrites over the whole frequency spectrum and compare their performance with silicon iron and powdered iron.

Selenium Rectifiers. O. S. Aikman. *Machine Design*, Vol. 23, No. 4, April, 1951, pp. 163–172, illus. Construction of the selenium rectifier stack, fundamental circuits, rectifier characteristics, industrial applications.

Magnetic Delay-Line Storage. An Wang. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 401–407, illus. 4 references.

Analysis of the performance and optimum operating conditions of a magnetic delay line. The line consists of a series of cores of a magnetic material having an almost rectangular hysteresis loop (Deltamax); binary digits are sent in at one end of the line and advanced from one core to the next by applying pulses.

CONSTRUCTION TECHNIQUES

Stamped Electrical Circuits Yield Compact, Low Cost Assemblies. Herbert Chase. *Materials & Methods*, Vol. 33, No. 4, April, 1951, pp. 78–81, illus. The Franklin Airloop Corp. process of stamping thin metal-strip conductors into dielectric materials.

Correlation of Circuit Diagram and Wiring Development of Electronic Systems. A. W. Keen. *Electronic Engineering*, Vol. 23, No. 278, April, 1951, pp. 144, 145, illus.

ELECTRONIC TUBES

The Space-Charge Smoothing Factor. C. S. Bull. (*I.E.E., Radio Section, Paper No. 1082.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 52, March, 1951, pp. 149–152, illus. 11 references.

Electronic Tracing of Tube Characteristics. Joseph Arnold. *Sylvania Technologist*, Vol. 4, No. 1, January, 1951, pp. 14–17, illus.

Amplification of the Traveling Wave Tube. Bernard Friedman. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 443–447, illus. 1 reference.

Effect of Hydrostatic Pressure in an Electron Beam on the Operation of Traveling-Wave Devices. Philip Parzen and Ladislas Goldstein. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 398–401, illus. 8 references.

High-Voltage Stabilization by Means of the Corona Discharge Between Coaxial Cylinders. S. W. Lichtman. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 419–424, illus. 11 references.

Construction features and performance characteristics of high-voltage regulating tubes; development of circuit-design relationships that permit the fitting of particular corona-regulator-tube characteristics to specific load-current and stability requirements.

Controllable Gas Diode. E. O. Johnson. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 107–109, illus. 2 references.

Construction and characteristics of the plasmatron, a hot-cathode helium-filled diode that operates at anode potentials as low as several volts and has a continuously controllable current output of hundreds of milliamperes. The small control current acts on an auxiliary discharge that provides ionization to neutralize space charge. Graphs show tube characteristics. The plasmatron can be used in low-frequency, low-impedance applications that require a continuously controllable circuit.

MEASUREMENTS & TESTING

A Resonant-Bridge Carrier System for the Measurement of Minute Changes in Capacitance. George W. Cook. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 626*, February, 1951. 37 pp., illus. 2 references.

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Theory, circuit design, and operation of a measurement system for resolving capacitance changes of 10^{-15} farads. The system uses a doubly resonant capacitance bridge circuit that is excited by a link-coupled-transformer form of crystal-stabilized oscillator of low or intermediate radio frequency.

Discussion on "A Source of Error in Radio Phase Measuring Systems," by R. Bateman, E. F. Florman, and A. Tait. Eberhardt Rechtin. **Authors' Reply.** *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 436–438, illus. 2 references.

Diffraction Errors in an Optical Measurement at Radio Wavelengths. G. A. Woonton, J. A. Carruthers, H. A. Elliott, and E. Caroline Rigby. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 390–397, illus. 4 references.

A Receiver for Measuring Angle-of-Arrival in a Complex Wave. Frederick E. Brooks, Jr. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 407–411, illus. 11 references.

Circuit arrangement and physical setup of a receiver that separates simultaneously received waves by means of signal-strength and phase-difference data received at three points. Phase difference is measured to an accuracy of 5° over a signal-strength range of 70 db. and a signal-strength ratio up to 20 db. between channels.

Wien Bridge As Frequency-Shift Servo. Jack Yeiser. *Electronics*, Vol. 24, No. 1, January, 1951, pp. 162, 164, illus. Its use as a frequency discriminator in servo applications.

NAVIGATION AIDS

En Route Navigation Systems and Air Traffic Control. Tankred von Hauteville. *Interavia*, Vol. 6, No. 3, March, 1951, pp. 161–166, illus. 7 references. Short distance (up to 125 miles from airport) aids to navigation; description of air-borne and ground installations and cockpit instruments of the VOR and Decca systems.

TRANSMISSION LINES

Surface-Wave Propagation over a Coated Plane Conductor. Stephen S. Attwood. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 504–509, illus. 1 reference.

Letters to the Editor: Propagation on Dielectric Coated Wires. E. T. Kornhauser. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, p. 525. 2 references.

Analysis of Symmetrical Waveguide Junctions. David M. Kerns. (Catholic University of America, Ph.D. Thesis.) *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 4, pp. 267–282, illus. 9 references. (Also available as *Research Paper No. 2195*. Superintendent of Documents, Washington. $0.10.)

Development of a general theory of the consequences of symmetry in waveguide junctions in which linear behavior and freedom from internal sources are assumed. The physical and mathematical formulation of the electromagnetic problem is developed. The symmetry of a waveguide junction is characterized by a group of rotation-reflection operations under which the structure is invariant. Three examples illustrate the symmetry method of analysis.

WAVE PROPAGATION

Low-Frequency Radio-Wave Propagation by the Ionosphere, with Particular Reference to Long-Distance Navigation. Caradoc Williams. (*I.E.E., Radio Section, Paper No. 991.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 52, March, 1951, pp. 81–99, Discussion, pp. 99–103, illus. 9 references.

The Effect of the Lorentz Polarization Term on the Vertical Incidence Absorption in a Deviation Ionosphere Layer. J. M. Kelso. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 4, April, 1951, pp. 412–419, illus. 15 references.

On the Scattering of Plane Waves by Soft Obstacles. I—Spherical Obstacles. Robert W. Hart and Elliott W. Montroll. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 376–386, illus. 19 references.

Scattering by a Prolate Spheroid. F. V. Schultz. *Michigan, University, Aeronautical Research Center, External Memorandum No. UMM-42*, March 1, 1950. 65 pp., illus. 26 references. Development of the solution for plane vector (electromagnetic) and scalar (sound) waves striking a prolate spheroid nose-on and the scattering of the waves by the spheroid.

Equipment

ELECTRICAL (16)

Simple Phase-Sequence Indicator. Alvin B. Kaufman. *Electronics*, Vol. 24, No. 5, May, 1951, pp. 172, 176, 181, 182, illus. Two lamps and one capacitor or inductor are used in a simple unit capable of field and test use.

HYDRAULIC (20)

Calculating the Energy Losses in Hydraulic Systems. Nils M. Sverdrup. *Product Engineering*, Vol. 22, No. 4, April, 1951, pp. 146–152, illus. Graphic methods of analysis; charts for frictional and energy loss coefficients in AN hydraulic fittings, circular pipes, and other elements used in hydraulic circuits.

Kinematic Viscosity Curves of Hydraulic Fluids (Reference Book Sheet). N. M. Sverdrup. *Product Engineering*, Vol. 22, No. 4, April, 1951, p. 173, illus.

Towards Hydraulic Serviceability. R. H. Bound and H. G. Conway. *The Aeroplane*, Vol. 80, No. 2071, March 30, 1951, pp. 385–387, illus. (Summary of an R.Ae.S. lecture, March 15, 1951: Progress Towards Hydraulic Serviceability.)

Design of "Fluid Bridge" Control Valves. Rodney B. Campbell. *Applied Hydraulics*, Vol. 4, No. 4, April, 1951, pp. 52–55, illus.

Fluid bridge valves work on Pascal's principle that pressures applied to confined fluids are transmitted equally in all directions. In a fluid-bridge control valve the fluid pressure flows into the inner chamber of the fluid bridge through one or more series of holes and flows out through another series of holes. Examples include shut-off, selector, and shuttle valves.

Pneumatic Power; Design and Application Fundamentals for Machine Drives and Controls. I—General Considerations. J. Alan Campbell. *Machine Design*, Vol. 23, No. 4, April, 1951, pp. 175–180, illus.

Flight Operating Problems (31)

CRUISE CONTROL

Cruise Control for Civil Airliners. C. J. O. Moorhouse. *Aeronautics*, Vol. 24, No. 3, April, 1951, pp. 61, 62, 65, 66, 69, illus. Factors that influence cruise conditions in piston-engined aircraft; cruising techniques; constant power to constant speed; long-range cruise control; presentation of cruise data in a cruise-control manual.

ICE PREVENTION & REMOVAL

An Investigation of Intermittent Heating for Aircraft Ice Protection. Frederick Weiner. *California, University, Los Angeles, M.S. in Engineering Thesis*, December, 1950. 79 pp., illus. 18 references.

Study of the accrual of ice on an internally heated propeller blade in flight. An electric analog method is used to solve the heat-transfer equations. Investigation of the means of increasing the effectiveness of the anti-icing process led to the design of a new external heater configuration for propeller deicing.

Combating Ice in Gas Turbines; Advantages of Using Auxiliary Hot-Air Equipment. *Flight*, Vol. 59, No. 2203, April 13, 1951, pp. 414, 415, illus.

(Sikorsky) H-5 Rotor Anti-Icing System. E. J. Katzenberger. *Interavia*, Vol. 6, No. 3, March, 1951, pp. 159, 160. 1 reference.

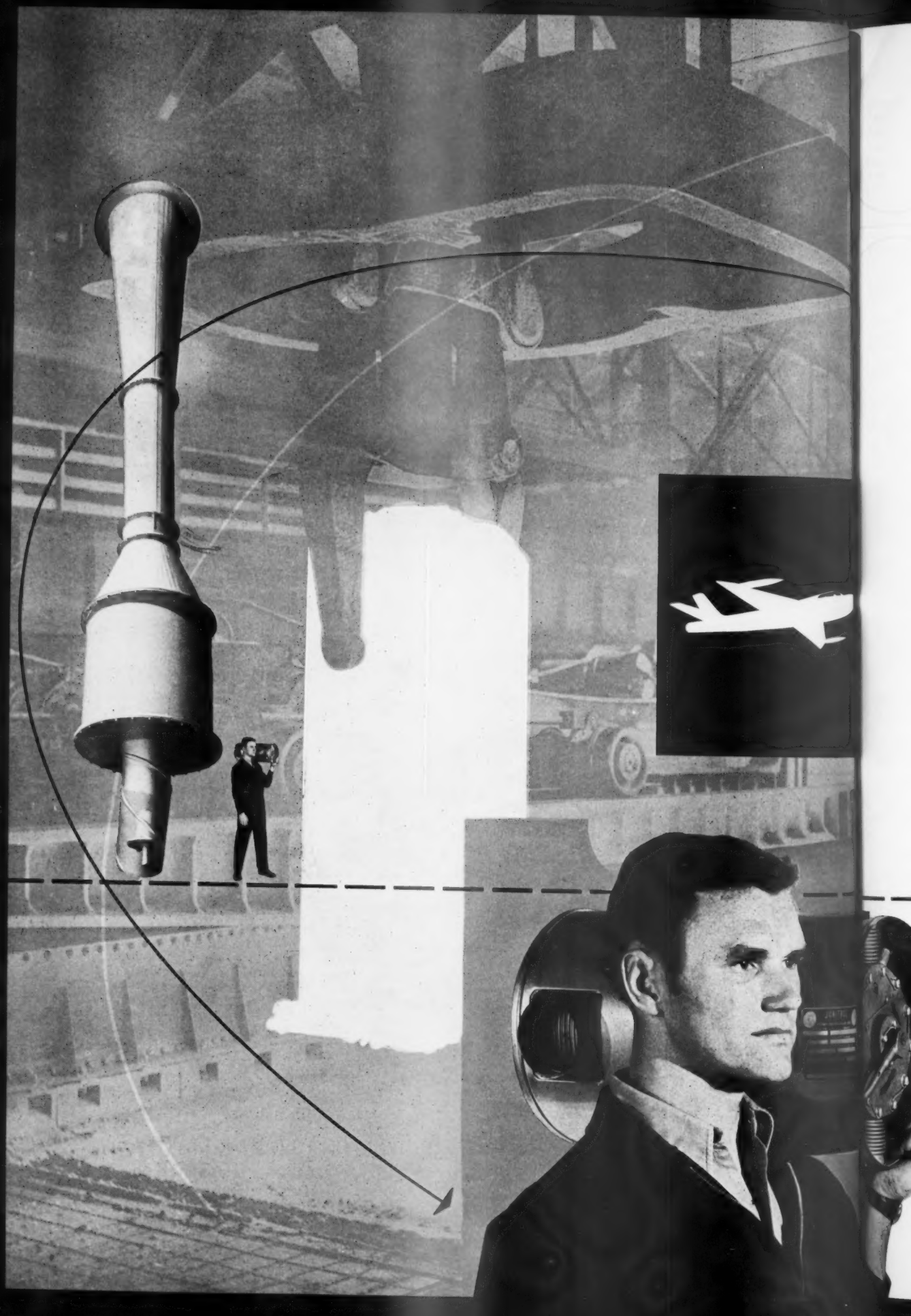
REFUELING IN FLIGHT

Engineer's Roundtable: Transport Refueling. F. W. Free. *Aero Digest*, Vol. 62, No. 4, April, 1951, pp. 29, 90.

Flight Safety & Rescue (15)

Research and Development to Promote Safety in Aviation. T. P. Wright. *SAE Quarterly Transactions*, Vol. 5, No. 2, April, 1951, pp. 173–190, Discussion, pp. 191–193. 31 references.

Chain You Can't Hook Up Wrong. *Aviation Week*, Vol. 54, No. 16, April 16, 1951, p. 45, illus. A new roller chain and sprocket



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Letter to the Editor: Stalling Risks with Civil Aircraft. L. Constantin. *Aircraft Engineering*, Vol. 23, No. 266, April, 1951, p. 111, illus. Design and performance of the weather-vane incidence indicator designed by the author.

Flight Testing (13)

Flight Measurements of Profile Drag at High Speeds. W. A. Mair. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2555*, 1951 (July, 1942). 11 pp., illus. 5 references. British Information Services, New York. $0.65.

Profile-drag measurements were made on a Tornado P.5224 with a wing section 18 per cent thick at flight Mach Numbers (in both level flight and dives) up to 0.7. A comb of 17 pitot tubes and two static tubes was fixed behind the starboard wing, and the pressures were measured by an air-speed indicator.

Series Testing the Scandia. A. Helgstrand. *Saab Sonics*, No. 13, January–March, 1951, pp. 12–15, illus.

Accelerated service tests, comprised of several hundred flight hours, on the Scandia prior to its commercial operation. The plane was fitted with specially designed measuring equipment.

Correspondence: "A Note on the Time Required To Make a Level Speed Measurement with a Turbine-Jet Aircraft" by K. J. Lush. O. N. Lawrence. **Author's Reply.** *Royal Aeronautical Society, Journal*, Vol. 55, No. 484, April, 1951, pp. 262–264, illus.

Fuels & Lubricants (12)

Refiners Improve Products for Personal Aircraft. W. V. Hanley. *SAE Journal*, Vol. 59, No. 4, April, 1951, pp. 49–53, illus. (Excerpts from a paper: Fuel and Lubricant Requirements of Personal Plane Aircraft Engines.)

An Apparatus for Studying Autoignition of Engine Fuels: Results with Normal Heptane and Normal Hexane. William J. Levedahl and Frank L. Howard. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 4, April, 1951, pp. 301–309, illus. 18 references. (Also available as *Research Paper No. 2200*. Superintendent of Documents, Washington. $0.10.)

Compression ratios greater than 18:1 were obtained with a modified single-cylinder ASTM-CFR supercharge method fuel-rating engine. Engine speeds were 600, 900, 1,200, and 1,800 r.p.m. The pressure-measuring equipment incorporated a Draper-Li strain gage unit. Attachment of a cylinder-pressure limiter permitted firing a small number of cycles, and combustion was recorded as pressure-crank angle oscillograms. Photographs show test results with *n*-heptane and *n*-hexane.

What Fuel Antiknock Quality Means in Engine Performance. H. E. Hesselberg and W. G. Lovell. *SAE Journal*, Vol. 59, No. 4, April, 1951, pp. 32–37, 43, illus. 2 references. (Excerpts from a paper: The Potentialities of Fuel Antiknock Quality.)

Evaluation of Packed Distillation Columns. I—Atmospheric Pressure. Thaine W. Reynolds and George H. Sugimura. *U.S., N.A.C.A., Technical Note No. 2342*, April, 1951. 24 pp., illus. 8 references.

Low-Temperature Lubrication of Turbojet and Turboprop Engines. Saul Barron. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 4, April, 1951, pp. 16–21, illus. 3 references.

Problems in cold-weather operation; turbine-engine lubricants and their behavior at temperatures down to −65°F.; results of U.S.A.F. experimental study of lubrication systems and lubricants with the J-31, J-33, J-35, J-47, T-34, and T-40.

Physics of Lubrication; A Symposium Held Jointly by the British Rheologists' Club and the Manchester and District Branch of The Institute of Physics in Manchester from 29 June to 1 July, 1950. *British Journal of Applied Physics, Supplement No. 1*, 1951. 96 pp., illus. 189 references. The Institute of Physics, London. 15*s*.

Contents. **Part 1—Hydrodynamic Lubrication and the Rheology of Lubricants:** Hydrodynamic Lubrication; General Survey, D. G. Christopherson. The Rheology of Lubricant Films, E. W. J. Mardles. Viscosity of Lubricating Oils at High Rates of Shear, A. F. H. Ward, S. M. Neale, and N. F. Bilton. The Lubrication of Cotton and Other Textiles, E. Moss.

Part 2—Boundary Layer and Extreme Pressure Lubrication: An Introduction to Boundary Layer and Extreme Pressure Lubrication, D. Claton. The Boundary Layer, G. I. Finch. Scuffing Temperatures of Boundary Lubricant Films, T. B. Lane. Lubrication with Materials in the Solid State, F. T. Barwell and A. A. Milne. The Lubrication of Rough Steel Surfaces by a Series of Metallic Soaps, F. T. Barwell and A. A. Milne. The Lubrication of Metals by Long Chain Organic Compounds, K. V. Shooter. A Study of Boundary Lubricant Films by Electron Diffraction, J. W. Menter. The Absorption of Lubricant Films; A Study by Radioactive Tracers, A. C. Moore. The Spreading Behaviour and Lubricating Properties of Mixed Liquids, E. Bielak, E. W. J. Mardles, and E. Tingle. The Electrostatic Component of the Force of Friction, R. Schnurmann. Physical Changes in Rubbing Surfaces on Scuffing, D. Clayton and C. H. M. Jenkins. Surface Welding and the Extreme Pressure Lubricant, G. I. Finch and R. T. Spurr. An Investigation of Surface Damage Using Radioactive Metals, E. Rabinowicz. The Effect of Lubrication on Friction, Wear, and Abrasion, P. Grodzinski.

A subject and a name index to the papers are included. References are given at the ends of papers. The name index covers authors of papers, discussers, and authors of works referred to.

Static Friction Tests with Various Metal Combinations and Special Lubricants. H. S. White and Dino Zei. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 4, April, 1951, pp. 292–298, illus. (Also available as *Research Paper No. 2198*. Superintendent of Documents, Washington. $0.10.)

Static-friction data for chlorinated and fluorinated hydrocarbons are tabulated and plotted. The data were obtained with an inclined-plane test apparatus for metal combinations of stainless and carbon steels, cast iron, aluminum alloy and chromium plate. Navy symbol 2110 oil was used as the reference lubricant.

Lubrication at Extreme Pressures with Mineral Oil Films. O. H. Clark, W. W. Woods, and J. R. White. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 474–483, illus. 14 references.

Experiments demonstrating lubrication by intact mineral-oil films at pressures ranging from 86,000 to 215,000 lbs. per sq.in. A crossed-cylinder bearing apparatus developed for the studies and the shear-strength apparatus are described. Test results are presented in photomicrographs, tables, and graphs.

Hydrides and Organometallic Compounds As High Energy Rocket Fuels. Norman Bowman and Wayne Proell. *Journal of Space Flight*, Vol. 2, No. 1, January, 1950, pp. 6–9, tables.

An Analog Computer for Flame Gas Composition. William S. McEwan and Sol Skolnik. *Review of Scientific Instruments*, Vol. 22, No. 3, March, 1951, pp. 125–132, illus. 3 references.

Design and operation of an analog computer for the calculation of the system of equations containing the unknown concentrations of reaction products for propellant systems to obtain the specific impulse of the system.

Nitrogen Fuel Storage Vessel for Missiles. *Aviation Age*, Vol. 15, No. 4, April, 1951, p. 29, illus.

Spherical storage vessels, fabricated by Research Welding and Engineering Co., for liquid nitrogen is 54 in. in diameter, constructed of spherical stainless-steel segments, and holds 200 gal. of liquid nitrogen at 5,500 lbs. pressure at −340°F.

Composition of the Products of Reaction of Gasoline and Liquid Oxygen. R. N. Wimpress and B. H. Sage. *California Institute of Technology, Jet Propulsion Laboratory, GALCIT Project No. 1, Progress Report No. 19*, March 8, 1944. 17 pp., illus. 4 references. Computation of the equilibrium composition of the reaction products and of the effects of varying the oxidant-fuel weight ratio and of increasing the reaction pressure.

Gliders (35)

Some Effects of Altitude. B. H. Carmichael. *Soaring*, Vol. 15, No. 2, March-April, 1951, pp. 2, 14, illus. Study of the effects of altitude on sinking speed, turning ability, and general performance of a sailplane.

The Standing Wave. Ginny and Steve Bennis. *Flight Magazine*, Vol. 35, No. 4, April, 1951, pp. 16, 17, 26, 27, illus. Sailplane flights in standing-wave updrafts; piloting techniques.

A Practical Electric Variometer. R. H. Ball. *Soaring*, Vol. 15, No. 2, March-April, 1951, pp. 3–5, 15, illus. 7 references. Design of hot-wire and thermistor variometers that can be used in a rate-of-climb indicator system.

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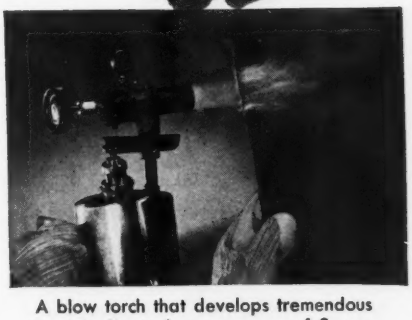

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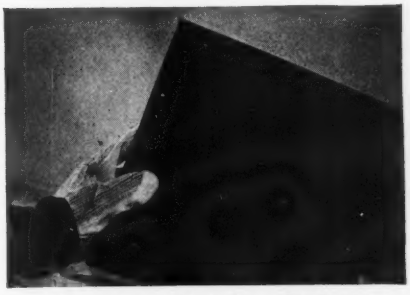

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The Peravia Barograph for Soaring Performance Studies. August Raspet and Mel Swartzberg. *Soaring*, Vol. 15, No. 2, March-April, 1951, pp. 6–8, 14, illus.

Guided Missiles (1)

Woomera; Post-War Progress with British Guided Missiles; The Australian Rocket Range. *Flight*, Vol. 59, No. 2203, April 13, 1951, pp. 429–431, illus.

The Perturbation Calculus in Missile Ballistics. R. Drenick. *Franklin Institute, Journal*, Vol. 251, No. 4, April, 1951, pp. 423–436, illus. 3 references.

Adaptation of the calculus of perturbation to the study of flight control of rocket missiles and the derivation of criteria for missile guidance. A guidance concept for the free-flight portion of the missile trajectory is obtained from the form of the calculus of perturbations which is applied to controllable missiles.

The Stability and Response of an Aerodynamic Missile in Plane Motion. H. G. Mazurkiewicz and Richard M. Spath. *Michigan, University, Aeronautical Research Center, Memorandum No. UMM-37*, December, 1949. 41 pp., illus. 4 references.

Analysis of the stability of a rocket-propelled missile in linearized pitch plane motion. Solutions are developed for the motion of the missile and its response to general forcing functions. From the general forcing functions, a general response theory is obtained. Amplitude and phase invariants are calculated in terms of the roots of the characteristic equation.

Instruments (9)

Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method. James B. Rea. (*Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950.) *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1950, pp. 375–397, illus. 17 references.

Single Curve Simplifies Control. *Aviation Week*, Vol. 54, No. 16, April 16, 1951, pp. 26, 28, 30, illus.

A simplified control system is based on the relation between the ratio of aileron to rudder deflection for a given elevator setting. Dr. Frederick W. Ross, University of Detroit, developed a mechanical computer based on this relation which is a modified control linkage that replaces the standard system with a stick and trim lever. The system was flight tested in an Aeronca 7AC but is adaptable to all aircraft.

Capacitive Slip Ring for Instrumentation. F. P. Fischer and C. H. Coogan, Jr. *Electronics*, Vol. 24, No. 1, January, 1951, pp. 84, 85, illus. 2 references. Thermistor elements are connected to an r.f. bridge by capacitor rings for temperature measurements on rotors at speeds greater than 20,000 r.p.m.

A Practical Electric Variometer. R. H. Ball. *Soaring*, Vol. 15, No. 2, March-April, 1951, pp. 3–5, 15, illus. 7 references. Design characteristics of hot-wire and thermistor electrical variometers; circuit diagrams; comparison of performance and specifications.

Flight by Periscope. I—Performing an Instrument Flight Pattern; the Influence of Screen Size and Image Magnification. Stanley N. Roscoe. *Illinois, University, Institute of Aviation, Aeronautics Bulletin, No. 9*, March, 1951. 46 pp., illus. 9 references.

Comparison of pilot performance using a pictorial attitude display with contact visibility; effects on pilot performance of display size and image magnification. The "periscope" unit, which contains no prisms or mirrors, was mounted in a Cessna T-50, with the screen directly above the instrument panel. The optical system consists of 5 lenses mounted in tandem. Flight-test procedure and experimental results are analyzed.

Behind the Dial. C. Williams. *Shell Aviation News*, No. 153, March, 1951, pp. 14, 15, illus. Mechanical problems and their solutions in the design of instruments at Smith Aircraft Instruments Ltd.

The Peravia Barograph for Soaring Performance Studies. August Raspet and Mel Swartzberg. *Soaring*, Vol. 15, No. 2, March-April, 1951, pp. 6–8, 14, illus. Operation and interpretation of barograms.

Letter to the Editor: Stalling Risks with Civil Aircraft. L. Constantin. *Aircraft Engineering*, Vol. 23, No. 266, April, 1951, p. 111, illus. Design and performance of the weather-vane incidence indicator designed by the author.

Wind-Tunnel Investigation of a Number of Total-Pressure Tubes at High Angles of Attack: Subsonic Speeds. William Gracey, William Letko, and Walter R. Russell. *U.S., N.A.C.A., Technical Note No. 2331*, April, 1951, 69 pp., illus. 3 references. Supersedes *U.S., N.A.C.A., Research Memorandum No. L50G19*, September 26, 1950.

A Non-Mathematical Discussion of Flow Measurement. J. B. McMahon. *Instruments*, Vol. 24, No. 4, April, 1951, pp. 470–477, illus. Theory, types of flowmeters, applications.

Evaluation of Selected Shock Instruments. Thomas A. Perls and Harry L. Rich. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 720*, February, 1951. 58 pp., illus., fold. charts. 24 references. Steady-state and shock tests on velocity meters, accelerometers, multifrequency reed gages, and ball-crusher gages.

Applications of Bonded Wire Strain Gages. Francis G. Tatnall. *The Tool Engineer*, Vol. 26, No. 4, April, 1951, pp. 28–31, illus.

Compression Test Extensometer for Cylindrical Specimens. A. M. Stott and J. M. McCaughey. *Product Engineering*, Vol. 22, No. 4, April, 1951, pp. 157–160, illus. 4 references.

Design and development of an extensometer that can be used for ferrous and nonferrous materials at temperatures of −70°F. to 400°F. The instrument uses SR-4 wire resistance strain gages. Calibration and test procedure are explained.

The Direct-Reading D-C Strain-Gage Bridge. I. Robert W. Troke. *Instruments*, Vol. 24, No. 4, April, 1951, pp. 400, 401, 450–452, 454, 456, 458, illus. Types of strain-gage bridges, calibrations, practical considerations, applications.

Laboratory and Workshop Notes: Resistance Calibration Steps. S. P. Hillson. *Journal of Scientific Instruments*, Vol. 28, No. 4, April, 1951, p. 122, illus. 1 reference. Calibration strain-gage recording apparatus by means of the decade shunt principle in which the resistance is divided into a number of intervals.

Methods for Connection to Revolving Thermocouples. Philip R. Tarr. *U.S., N.A.C.A., Research Memorandum No. E50J23a*, January 18, 1951. 28 pp., illus. 4 references. Electrical connections to thermocouples that are revolving at high speeds by means of a slip ring and brush system.

An Electronic Instrument for the Measurement of the Damping Capacity of Materials. A. D. N. Smith. *Journal of Scientific Instruments*, Vol. 28, No. 4, April, 1951, pp. 106–109, illus. 4 references. An instrument for measuring the rate of decay of any vibration that is exponential and in the frequency range of 50–10,000 cycles per sec.

Machine Elements (14)

FASTENINGS

Fatigue Durability of Prestressed Screw Threads. J. O. Almen. *Product Engineering*, Vol. 22, No. 4, April, 1951, pp. 153–156, illus. 6 references.

Proper machinability of screw threads increases durability and prevents excessive internal stress. Rolling of threads prevents fatigue failures in the core. Fatigue durability test comparisons of screw threads showed the strength before and after prestressing with rollers.

Fasteners of Non-Ferrous Alloys and Stainless Steels. M. N. Veeder. *Fasteners*, Vol. 7, No. 1, 1951, pp. 7–10, tables.

MECHANISMS & LINKAGES

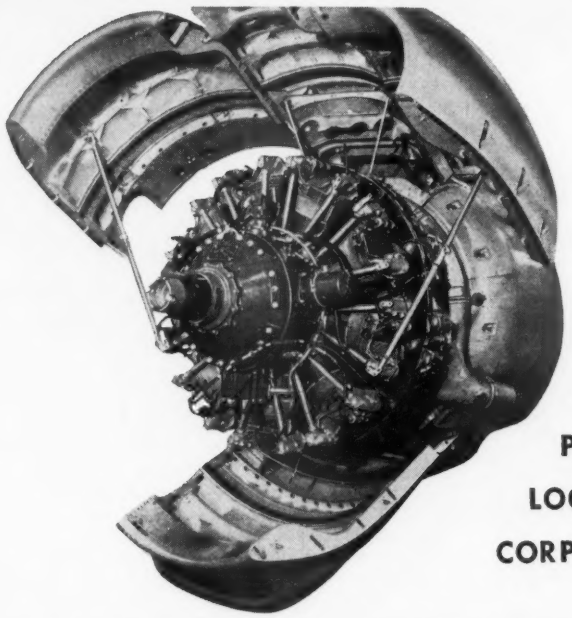
Push-Pull and Torque Tubes. J. J. Sloan. *Machine Design*, Vol. 23, No. 4, April, 1951, pp. 143–147, illus. Survey of aircraft types of push-pull rod and torque assemblies; comparison of their functions and fabrication; a knurled-swaged method of manufacture.

SPRINGS

Methods of Spiral Spring Design; A Mathematical Treatment for Determining the Physical Dimensions and Behaviour Under Straining Action. B. Alexander. *Aircraft Engineering*, Vol. 23, No. 266, April, 1951, pp. 113–116, illus.

TRANSMISSIONS, CLUTCHES, & DRIVES

Improved Magnetic Fluid Clutch (N.B.S.). *Product Engineering*, Vol. 22, No. 4, April, 1951, pp. 114–116, illus., cutaway drawings.



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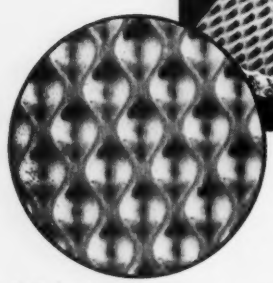

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Maintenance (25)

Guide to Equipment Overhaul Times. *Aviation Week*, Vol. 54, No. 17, April 23, 1951, pp. 37–41, illus. Tables for the overhaul and replacement times in hours set by air lines for operation of the Martin 2-0-2, Boeing 377, Convair 240, Douglas DC-6, and Lockheed L-649-749 and L-49.

Douglas Service. Vol. 9, No. 2, March-April, 1951. 20 pp., illus. C-47, C-54DC, DC-3, DC-4, DC-6, and DC-6B.

Materials (8)

The Equilibrium of Linear Arrays of Dislocations. J. D. Eshelby, R. C. Frank, and F. R. N. Nabarbo. *Philosophical Magazine*, Vol. 42 (7th Series), No. 327, April, 1951, pp. 351–364. 16 references.

Interpretation of the plastic behavior of solids in terms of dislocations. The equilibrium positions of a set of identical dislocations (assumed to be of infinite length and parallel to one another) are given by the roots of a set of orthogonal polynomials.

An Automatic Light-Load Bergsman Type Hardness Tester. P. Grodzinski. *Journal of Scientific Instruments*, Vol. 28, No. 4, April, 1951, pp. 117–121, illus. 6 references.

Automatic control by means of a motor drive and redesign of the indenter to a double-cone having an edge adapted to the Bergsman microhardness tester to permit the application of loads up to 3,000 *g*.

The Use of Plasticine Models to Simulate the Plastic Flow of Metals. A. P. Green. *Philosophical Magazine*, Vol. 42 (7th Series), No. 327, April, 1951, pp. 365–373, illus. 7 references.

Examination of the mechanical properties that plasticine, or a similar substance, should have for its manner of deformation to approximate closely the deformation of an ideal metal in flow of two and three dimensions. Experimental procedure is explained; results verify theory.

CERAMICS & CERAMALS

High-Temperature Protection of a Titanium-Carbide Ceramal with a Ceramic-Coating Having a High Chromium Content. Dwight G. Moore, Stanley G. Benner, and William N. Harrison. *U.S., N.A.C.A., Technical Note No. 2329*, March, 1951. 31 pp., illus. 3 references.

Study of the protection against oxidation of cobalt-bonded titanium-carbide (Kennametal K-138) ceramal by a ceramic-metal coating (A-479M) containing a high content of chromium powder; laboratory tests of adherence and shock resistance of the coating.

METALS & ALLOYS

A Theory of the Plastic Distortion of a Polycrystalline Aggregate Under Combined Stresses. J. F. W. Bishop and R. Hill. *Philosophical Magazine*, Vol. 42 (7th Series), No. 327, April, 1951, pp. 414–427. 11 references.

The macroscopic theory of plasticity; plastic distortion of a single crystal; plastic deformation of a polycrystalline aggregate, assuming that the measuring device gives an average value of stress or strain over a large number of crystals.

Fatigue Strengths of Aircraft Materials; Axial-Load Fatigue Tests on Unnotched Sheet Specimens of 24S-T3 and 75S-T6 Aluminum Alloys and of SAE 4130 Steel. H. J. Grover, S. M. Bishop, and L. R. Jackson. *U.S., N.A.C.A., Technical Note No. 2324*, March, 1951. 66 pp., illus. 17 references.

Fasteners of Non-Ferrous Alloys and Stainless Steels. M. N. Veeder. *Fasteners*, Vol. 7, No. 1, 1951, pp. 7–10, tables.

High Temperature Structure and Thermal Expansion of Some Metals As Determined by X-Ray Diffraction Data. I—Platinum, Tantalum, Niobium, and Molybdenum. James W. Edwards, Rudolph Speiser, and Herrick L. Johnston. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 424–428, illus. 17 references.

Results of an investigation of the crystal structure and thermal expansion in the temperature range of 1,100° to 2,500°K. Quadratic equations were developed for the thermal expansion of each metal, from which values of the expansion coefficient were obtained by differentiation.

Residual Grinding Stresses in Mild Steel. J. Frisch and E. G. Thomsen. *American Society of Mechanical Engineers, Transac-*

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tions, Vol. 73, No. 3, April, 1951, pp. 337–342, Discussion, pp. 342–346, illus. 6 references.

Fracture Under Combined Stress Creep Conditions of a 0.5 Per Cent Mo Steel. A. E. Johnson. *The Engineer*, Vol. 191, No. 4967, April 6, 1951, pp. 434–437, illus. 2 references.

Pure tension, pure torsion, and combined stress creep tests were made on a 0.5 per cent Mo steel at a temperature of 550°C. to examine the validity of the Siegfried hypothesis of fracture under combined stress creep conditions and to establish a criterion of fracture. The results obtained cannot be explained upon the basis of the Siegfried criterion, and the criterion of fracture is apparently the maximum principal stress.

Microscopical Examinations of Creep Specimens. E. A. Jenkinson. *The Engineer*, Vol. 191, No. 4968, April 13, 1951, pp. 469–472, illus. 1 reference. Photographs of internal structure of 0.5 per cent molybdenum steel after creep tests.

Nickel-Aluminum Alloy (Duranickel) Combines Strength and Corrosion Resistance. Philip O'Keefe. *Materials & Methods*, Vol. 33, No. 4, April, 1951, pp. 73–77, illus.

Some Properties of High-Purity Sintered Wrought Molybdenum Metal at Temperatures up to 2400°F. R. A. Long, K. C. Dike, and H. R. Bear. *U.S., N.A.C.A., Technical Note No. 2319*, March, 1951. 75 pp., illus. 11 references.

Investigation of tensile-strength properties; stress-rupture properties, fracture types, directional tensile properties of rolled plate, and metallography; effects of swaging, recrystallization, and area on the tensile strength.

Creep of High-Purity Aluminum. William D. Jenkins. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 4, April, 1951, pp. 310–317, illus. 14 references. (Also available as *Research Paper No. 2201*. Superintendent of Documents, Washington. $0.10.)

Tension tests were made on cold-drawn round aluminum bars at 105°F. to determine effects of variation of creep rate on the mechanism of deformation: Photographs show the creep effects on the microstructure and the fracture characteristics.

Quenching Process for Aluminum. Gilbert C. Close. *Aviation Age*, Vol. 15, No. 4, April, 1951, pp. 30, 31, illus.

A fog-and-water quenching process, developed at Northrop Aircraft, Inc., passes the heat-treated aluminum into a fog chamber for a short period (12 to 15 sec.) before immersing the metal in cold water. This process reduces warpage of the aluminum parts.

Development of Magnesium-Cerium Forged Alloys for Elevated-Temperature Service. K. Grube, R. Kaiser, L. W. Eastwood, C. M. Schwartz, and H. C. Cross. *U.S., N.A.C.A., Technical Note No. 2325*, March, 1951. 91 pp., illus., tables. 8 references. Alloy development; correlation of composition and structure with creep resistance.

NONMETALLIC MATERIALS

Outdoor Weather Aging of Plastics Under Various Climatological Conditions. S. W. Yustein, R. R. Winans, and H. J. Stark. *American Society for Testing Materials, Bulletin*, No. 173, April, 1951, pp. 31–43, illus. 7 references.

Summary of results obtained for the first 12 months of a 3-year program to study the effect of outdoor weather aging on five types of clear transparent sheet plastics, six types of laminated materials, and five types of molded terminal bars.

PROTECTIVE COATINGS

Surface Treatment and Finishing of Light Metals. VII—The Industrial Anodizing of Aluminium and Its Alloys. S. Wernick and R. Pinner. *Sheet Metal Industries*, Vol. 28, No. 288, April, 1951, pp. 373–379, 383, illus. 20 references.

SANDWICH MATERIALS

Note on Bending of Thick Sandwich Plates. George Gerard, *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 424–426, 432, illus. 5 references. Development of a system of equations for the bending of thick isotropic sandwich plates.

Buckling of Sandwich Cylinders Under Axial Compression. F. K. Teichmann, Chi-Teh Wang, and George Gerard. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 398–406, illus. 3 references.

Obtaining of the buckling of sandwich circular cylinders under axial compression by solving the differential equations. A solution of the buckling load is obtained in a nondimensional form as a function of the sandwich cylinder parameters. Test results agree well with theory.

Meteorology (30)

The Mechanism of Dissolution of the Atmospheric Chloride into Rain Water. Y. Miyake and Y. Sugiura. *Papers on Meteorology and Geophysics*, Vol. 1, No. 2–4, December, 1950, pp. 222–226, illus. 5 references.

A Formation of Pileus-Like Veil Clouds over Cape Cod, Massachusetts. Joanne Starr Malkus, Andrew F. Bunker, and Kenneth McCasland. *American Meteorological Society, Bulletin*, Vol. 32, No. 2, February, 1951, pp. 61–66, illus. 10 references.

Study of convection and cumulus clouds formed from low-altitude veil clouds by means of airplane traverses and soundings in the cloud area and local synoptic data. The cumulus cloud formation is a specialized outgrowth of the convergence caused by land-sea temperature contrast.

The Evaporation, Temperature and Thermal Relaxation-Time of Freely Falling Waterdrops. Gilbert D. Kinzer and Ross Gunn. *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 71–83, illus. 15 references.

Theoretical and experimental study. Raindrops considered are those that fell at a speed sufficient to ventilate the transition layer of vapor and temperature and that were not deformed during falling. Reynolds Numbers ranged from 7 to 2,000.

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Effect of Sunlight on the Action of Silver Iodide Particles As Sublimation Nuclei. S. E. Reynolds, Wm. Hume, II, Bernard Vonnegut, and Vincent J. Schaefer. *American Meteorological Society, Bulletin*, Vol. 32, No. 2, February, 1951, pp. 47–51, illus. 7 references.

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Comparison of Monthly Geostropic and Gradient Winds with Resultant Rawins. Eugene J. Aubert and Jay S. Winston. *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 126, 127. 2 references.

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On the Coupling Between Upper Waves and Surface Pressure Centers. S. Matsumoto. *Papers on Meteorology and Geophysics*, Vol. 1, No. 2–4, December, 1950, pp. 198–205. 4 references.

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On the Structure of the Jet Stream. M. Magata. *Papers on Meteorology and Geophysics*, Vol. 1, No. 2–4, December, 1950, pp. 175–187, illus. 3 references. Theoretical study of its origin, behavior, and characteristics.

Seasonal and Irregular Variations of the Northern Hemisphere Sea-Level Pressure Profile. Edward N. Lorenz. *Journal of Meteorology*, Vol. 8, No. 1, February, 1951, pp. 52–59, illus. 7 references.

On Permanent Perturbations of Zonal Atmospheric Motion, with Applications to Low Latitudes. Leon Sherman. (*California, University, Institute of Geophysics, Publication No. 5; Ph.D. in*

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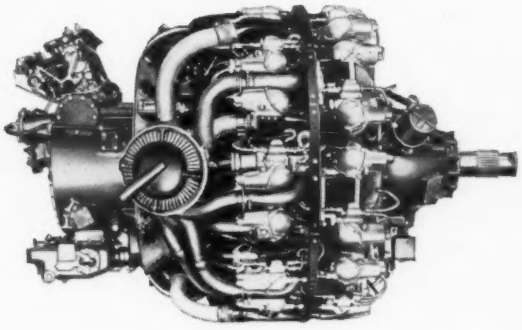

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Meteorology, Thesis.) *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 84–94, illus. 18 references.

A Theory of Entrainment in Convective Currents. Henry G. Houghton and Harrison E. Cramer. *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 95–102, illus. 9 references.

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The Conservation Law About the Horizontal of the Total Vorticity. H. Arakawa. *Papers in Meteorology and Geophysics*, Vol. 1, No. 2–4, December, 1950, pp. 170–172. 2 references.

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Land Breezes and Nocturnal Thunderstorms. J. Neumann. *Journal of Meteorology*, Vol. 8, No. 1, February, 1951, pp. 60–67, illus. 15 references.

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Kinematic features of symmetric tropical cyclones are derived from the vorticity and circulation theorems. It is determined from the integrals of pressure and kinetic energy that positive atmospheric vortices are surrounded by a region of negative relative vorticity; this conclusion is verified by data on the Okinawa typhoon of August, 1924. The latitude effect, rotation in the upper air layers, and generation of the eye are studied on the basis of the theorem of absolute circulation and the dynamic motion of air rings.

A Proposition on the Advection Problem. S. Matsumoto. *Papers on Meteorology and Geophysics*, Vol. 1, No. 2–4, December, 1950, pp. 211–216, illus. 6 references.

Correspondence: Tidal Effects in the Ionospheric F-Layer, by M. W. Jones and J. G. Jones. Sydney Chapman. **Reply.** *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 133, 134. 3 references.

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The Relation Between the Tropopause and Convective Activity in the Subtropics (Puerto Rico). Maurice E. Graves. *American Meteorological Society, Bulletin*, Vol. 32, No. 2, February, 1951, pp. 54–60, illus. 6 references.

On the Three-Dimensional Motions in an Outbreak of Polar Air. E. Palmén and C. W. Newton. *Journal of Meteorology*, Vol. 8, No. 1, February, 1951, pp. 25–39, illus. 26 references.

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Correspondence: Energy Transformation Functions, by James E. Miller. J. Van Meighem. **Reply.** *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 131–133. 5 references.

A Study of Atmospheric Heat-Sources in the Northern Hemisphere for Monthly Periods. Eugene J. Aubert and Jay S. Winston. *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 111–125, illus. 17 references.

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Calibration apparatus includes an automatic barometer to measure pressures in the test chamber. Charts show the barometer arrangement and the method of driving chart paper in the recorder at a speed proportional to test-chamber pressure changes.

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Recent Developments in Visual Low-Approach and Landing Aids for Aircraft. Maurice A. Garbell. (*Illuminating Engineering Society, Aviation Section, Annual Conference, Indianapolis, October 25, 1949.*) *Garbell Research Foundation, Garbell Aeronautical Series No. 1*, 1951. 19 pp., illus. 11 references. $0.60. Meteorological instruments for use with visual low-approach and landing aids.

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A Tau-Meter for Rapid-Response Temperature Recording Systems. L. J. Anderson and H. L. Heibeck. *American Meteorological Society, Bulletin*, Vol. 32, No. 2, February, 1951, pp. 67–71, illus.

Apparatus developed by the U.S. Navy Electronics Laboratory for evaluating systems having τ values of 0.2 to several seconds. The sensing element is suspended alternately for a series of equal time intervals in two air streams of different temperature. The indicated-actual temperature difference ratio is used to obtain the lag coefficients. The relation between τ and response-ratio R is derived to obtain the errors in the system.

Improved Code Sending Type Radiosonde. K. Isono and Y. Huziwara. *Papers on Meteorology and Geophysics*, Vol. 1, No. 2–4, December, 1950, pp. 299–312, illus. 14 references.

Correspondence: Microwave Determination of Particle-Size Distribution. Shepard Vartnoff and David Atlas. *Journal of Meteorology*, Vol. 8, No. 2, April, 1951, pp. 130, 131. 3 references.

Results of Synoptic Tests Applied to Certain Forecasting Rules. Henry T. Harrison. *American Meteorological Society, Bulletin*, Vol. 32, No. 3, March, 1951, pp. 89–96, illus. 6 references. Qualitative synoptic tests are applied to a group of 25 forecasting "rules," most of which deal with the problem of utilizing upper-air data in conjunction with the surface chart in airway forecasting.

The Development of a Method of Estimating and Forecasting Winds at 10,000 Feet over the North Atlantic. H. H. Lamb. (*Ireland, Meteorological Service, Technical Note No. 4*, January 14, 1943.) *Ireland, Meteorological Service, Geophysical Publications*, Vol. 3, No. 3, 1951. 14 pp., illus. Government Publication Sale Office, Dublin. 5*s*.

United Air Lines and Its Weather Service. H. T. Harrison. *American Meteorological Society, Bulletin*, Vol. 32, No. 3, March, 1951, pp. 104–107, illus.

Wind Convergence As a Factor in Persistent Radiation Fog. Aili Nurminen. *American Meteorological Society, Bulletin*, Vol. 32, No. 2, February, 1951, pp. 72, 73, illus. 3 references.

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The Air Force Procurement and Expansion Program. John A. McCone. *Aeronautical Engineering Review*, Vol. 10, No. 6, June, 1951, pp. 12–15.

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Ground Attack Missions and the Jet. M. Wüthrich. *Interavia*, Vol. 6, No. 2, February, 1951, pp. 103–106, illus. Diagrammatic analysis of the performance of a jet aircraft in ground-attack operations and its advantages and disadvantages; problem of the lack of proper armament.

Trajectories of Interception. *Interavia*, Vol. 6, No. 2, February, 1951, pp. 108–110, illus.

Analysis of several trajectories: curve of pursuit, path of encounter or of future position, curve of alignment, accelerated curve of alignment trajectory to probable position, and curve of pursuit to avoid interception.

Soviet Naval Aviation. *Naval Aviation News*, April, 1951, pp. 14–17, illus. Organization of the Soviet naval air arm; photographs and details of some Soviet aircraft.

Navigation (29)

Practical Aspects of High Speed Navigation. John Langston. *Navigation*, Vol. 2, No. 9, March, 1951, pp. 305–312. Problems that arise in the navigation of jet aircraft because of the operating

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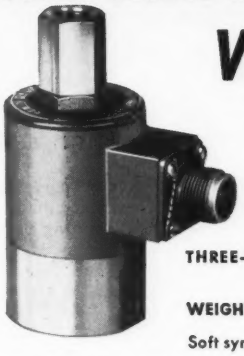

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characteristics of jets; effects of fuel consumption and upper-air winds; instrumentation problems; celestial navigation.

Grid Navigation—Global Requirement. L. F. Banks. *Navigation*, Vol. 2, No. 9, March, 1951, pp. 324–330, illus. (Condensation of a paper: Grid Navigation in All Latitudes.)

Navigational need for a direction-determination procedure that is not based on the conventional latitude-longitude lattice; conformal conic and Mercator projections; magnitude of lattice error.

A Short Method for Precomputation. Samuel Herrick. *Navigation*, Vol. 2, No. 9, March, 1951, pp. 321–324, illus. Precomputation of celestial lines of position; method of using precomputed data.

Annual Summary of Progress in Navigational Science, 1950. Institute of Navigation, Technical Committees. *Navigation*, Vol. 2, No. 9, March, 1951, pp. 332–340.

En Route Navigation Systems and Air Traffic Control. Tankred von Hauteville. *Interavia*, Vol. 6, No. 3, March, 1951, pp. 161–166, illus. 7 references.

Short distance (up to 125 miles from airport) aids to navigation. Aircraft and ground requirements indicate the need for accuracy, simplicity, speed of air-borne instruments, and the best utilization of airspace and landing runways. The VHF-UHF Instrument Landing System, VOR, and VOR cockpit instruments are briefly described. Hyperbolic navigation systems, such as the English Decca system, are explained and compared performance-wise with the VOR system.

Ordnance & Armament (22)

The Gyro Gun Sight. *Interavia*, Vol. 6, No. 2, February, 1951, pp. 106, 107, illus.

The G.G.S. March IV B gunsight, produced by Ferranti, Ltd., Edinburgh, which is a computing mechanism that takes into account the velocity and trajectory, range of the target, and allows for the turning of the attacking aircraft.

Parachutes

A Study of Bailouts for a Five-Year Period in the U.S. Navy. Walton L. Jones. *Journal of Aviation Medicine*, Vol. 22, No. 2, April, 1951, pp. 123–131, 155.

Photography (26)

Shock-Wave Shadow Photography in Tunnel and in Flight. I—Three-Dimensional Shock Wave Recorder. II—Shock Wave Photography in Flight. III—Shadow Phenomena of Shock Waves and the Effect of Optical Systems. F. E. Lamplough. *Aircraft Engineering*, Vol. 23, No. 266, April, 1951, pp. 94–103, illus. 2 references.

Parallel light is projected across the model and wave system and falls on a narrow horizontal slit in front of a photographic film or plate recording an element of the shadow picture. Rotating the system about the model produces a continuous contour at a specified level; contours at different levels give the three-dimensional picture. Light systems for tunnel and in-flight measurements include both fixed and moving lamps.

Kerr Cell Photography of High Speed Phenomena. E. M. Pugh, R. v. Heine-Geldern, S. Foner, and E. C. Mutschler. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 487–493, illus. 2 references.

Visible light silhouette photographs of metal jets are obtained by synchronizing, with the jet action, a light source obtained with an electrically exploded wire of peak intensity of 3 to 5×10^8 candlepower and a Kerr-cell shutter. Exposure time is 1 microsec. or less; an aerial lens with a focal length of 7 in. and an aperture of $f/2.5$ is used. Effective aperture, with Kerr cell, is $f/4$. Applied voltage on the Kerr cell is 25 kv.

Letters to the Editor: Transmission Line Kerr Cell. J. W. Beams and H. S. Morton, Jr. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, p. 523, illus. 1 reference.

A fast-acting Kerr-cell light-shutter arrangement in which almost any liquid showing the Kerr effect may be used. The Kerr constant and dielectric constant are of less importance than in the standard Kerr cell. Nicol prisms are oriented so that the plane of polarization makes a 45° angle with the lines of force between parallel plates. This acts as a Kerr-cell light shutter that is opened and closed by electrical impulses in the parallel-plate transmission line.

Investigation of the Flow Past Finite Wedges of 20 Deg. and 40 Deg. Apex Angle at Subsonic and Supersonic Speeds, Using a Mach-Zehnder Interferometer. D. C. Pack. **With Appendix: Sensitivity and Accuracy of the Interference Method Applied to Pressure Measurements.** E. Groth. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2321*, 1949 (May, 1946). 30 pp., illus. 6 references. British Information Services, New York. $1.40.

The theory, apparatus, and optical arrangement for obtaining photographs of the flow field by means of a Mach-Zehnder interferometer. The accuracy and sensitivity of the interference method are analyzed for the Mach Number range of the tests (M = 0.6–0.85, 1.4–2.8) with reference to the A7 high-speed tunnel at the Luftfahrtforschungsanstalt, Brunswick.

Airborne Magnetometer. T. O'Malley. *Engineering Journal*, Vol. 34, No. 3, March, 1951, pp. 177–179, illus.

High-sensitivity air-borne magnetometer, developed by Gulf Research & Development Co., which is used with the Sonne continuous-picture 35-mm. camera and a recording radio altimeter.

Power Plants

JET & TURBINE (5)

Exhaust Turbine and Jet Propulsion Systems. I—Exhaust Turbine and Jet Propulsion Systems. K. Leist. **II—Details on the Comparison of Special Power Plants.** E. Knörnschild. (*ZWB, Forschungsbericht Nr. 1069*, May, 1939.) *U.S., N.A.C.A., Technical Memorandum No. 1294*, April, 1951. 48 pp., illus. 1 reference.

Rearmament and the Aviation Gas Turbine. F. R. Banks. *The Aeroplane*, Vol. 80, No. 2073, April 13, 1951, pp. 438–440, illus. Problems in developing methods for increased British production of turbojet engines.

Experimental Evaluation by Thermodynamic Methods of Work Input to a Centrifugal Compressor Operating with Water Injection. Karl Kovach, William L. Beede, and Joseph T. Hamrick. *U.S., N.A.C.A., Research Memorandum No. E50J31*, January 12, 1951. 11 pp., illus. 2 references.

Analysis of Temperature Distribution in Liquid-Cooled Turbine Blades. John N. B. Livingood and W. Byron Brown. *U.S., N.A.C.A., Technical Note No. 2321*, April, 1951. 73 pp., illus. 8 references.

Mathematical analysis of one-dimensional spanwise, three-dimensional, one-dimensional chordwise, and two-dimensional chordwise temperature distribution equations for actual or simplified liquid-cooled turbine blades; comparative study of the applications of these analyses.

Allison Super Jet (J-35-A-23). *Aero Digest*, Vol. 62, No. 4, April, 1951, pp. 21, 50, 52, 85, illus.

Developed Mamba (Armstrong Siddeley ASM-3 Turboprop); Modifications to a Sound Basic Design Increase Power by 25 Per Cent. *Flight*, Vol. 59, No. 2201, March 30, 1951, pp. 369–371, illus., cutaway drawing.

Low-Temperature Lubrication of Turbojet and Turboprop Engines. Saul Barron. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 4, April, 1951, pp. 16–21, illus. 3 references. Problems in cold-weather operation; starting and preheating; types of oil; comparison of problems of dry-sump and wet-sump engines; test results.

Closed-Circuit Oil System for Turbojet and Turboprop Aircraft Engines. P. H. Schweitzer. *Aeronautical Engineering Review*, Vol. 10, No. 6, June, 1951, pp. 16–19, 22, illus. 3 references.

The main point is the use of the scavenge pump as a booster to the pressure pump, thus counteracting the drop in atmospheric pressure. The system also includes a deaerator and a device to replace consumed oil. Maximum usable altitude is 50,000 ft.

Flight Experience with Turbine Propeller Powered Aircraft. R. C. Loomis and E. D. Shannon. *S.A.E., National Aeronautic Meeting (Spring), New York, April 16–19, 1951, Preprint No. 616*. 13 pp., illus. 7 references.

Performance evaluation (flight) of the Convair 240 and Convair XP5Y-1 turboprop aircraft from the point of view of powerplant installation, operation, and precautions that must be observed for efficient and satisfactory turboprop performance.

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British Gas Turbine Starters. Paul H. Wilkinson. *Aviation Age*, Vol. 15, No. 4, April, 1951, pp. 36, 37, illus. Structural descriptions, operation and comparative performance of the Rotax, B.T.H., and Plessey starters for gas-turbine engines.

Definition and Measurement of Jet Engine Thrust. Bengt Jakobsson. *Royal Aeronautical Society, Journal*, Vol. 55, No. 484, April, 1951, pp. 226–243, illus. 8 references.

Theoretical study of a procedure for determining accurately the static thrust. Economical methods of determining flight thrust are suggested. The jet contraction effect is assumed to be particularly important.

Flame Propagation Velocities Under Pressure. Glen E. Eggleston. *Trend in Engineering*, Vol. 3, No. 2, April, 1951, pp. 28, 29, illus. Burner vibration problems arising from the oscillation of the flame front, causing blowout in jet engines.

RECIPROCATING (6)

The Development of the de Havilland Series of Engines for Light Aircraft. J. L. P. Brodie. *The Engineer*, Vol. 191, No. 4968, April 13, 1951, pp. 486–489, illus. (Abstract of a paper presented before the Institution of Mechanical Engineers, April 10, 1951.)

Thermal Stresses in a Piston and Cylinder of an Air-Cooled High Speed Internal Combustion Engine (Aero-Engine). II—Thermal Stresses in an Air-Cooled Cylinder. III—Thermal Stresses in Bodies of Revolution of Finite Dimensions, Due to Periodic Temperatures, Rapidly Increasing Temperatures and Axially Directed Stationary Heat Flow. G. Broersma. *Indonesia, Office for Scientific Research, Publications Nos. 18, 19*, August 7, 1950. 44 pp., illus. 30 references.

II. Investigation of the stresses and deformations due to stationary heat flow and of the effects of the gas pressures on the stresses. **III.** Calculation of the thermal stresses due to fluctuating temperatures of cylinders, pistons, and cylinders of uniform wall thickness with uniformly spaced cooling fins.

Wide Application for Automatic Fuel Pump. *Product Engineering*, Vol. 22, No. 4, April, 1951, p. 175, illus., cutaway drawing.

The Bendix electric automatic fuel pump provides a steady output of fuel up to 30 gal. per hr. at static pressures up to 7 lbs. per sq.in. and temperatures down to −75°F. A solenoid, controlled by an interrupter in the electrical circuit, actuates a hollow plunger that periodically delivers a fixed quantity of fuel to the carburetor.

Low-Tension Ignition System. W. Beye Smits and P. F. H. Maclaine Pont. *SAE Journal*, Vol. 59, No. 4, April, 1951, pp. 61–64, 69, illus. (Based on a paper: Smitsvonk Low-Tension Capacity Ignition System.)

The Smitsvonk system makes use of the tendency toward electrical leakage along the surface of an insulator; it can operate efficiently at engine speeds up to 40,000 r.p.m. and at high altitudes. The spark plug, suitable for all kinds of internal combustion engines, has little tendency to preignition, has accurate timing, is insensitive to fuel types, and is waterproof. The sparking element is made as a separate unit that can be easily fitted into different plug sizes.

How Large Can the Gaps Be? C. E. Swanson and J. W. Miller. *SAE Quarterly Transactions*, Vol. 5, No. 2, April, 1951, pp. 283–291, illus.

Investigation, by simulating engine operating conditions, to determine the maximum permissible spark-plug gap that can be fired by voltage transmitted through the spark-plug barrel. Curves show test results.

Analysis of the Exhaust Process in Four-Stroke Reciprocating Engines. J. D. Stanitz. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 3, April, 1951, pp. 319–326, Discussion, pp. 326–329, illus. 14 references.

Influences of engine design and engine operating variables on the exhaust process. A range of factors in the engine exhaust are investigated to determine their relative importance.

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Tests Show Value of Press-Forging. *Aviation Week*, Vol. 54, No. 17, April 23, 1951, pp. 50, 54, illus.

Results of preliminary study by Lockheed Aircraft Corp. and Wyman-Gordon Co. for the U.S.A.F. of press-forging methods of manufacturing integrally stiffened structures. Press size, power supply, and effects of the process on standard (aircraft) metals and alloys were studied.

Developments in Large Closed Die Forging. E. O. Dixon. *SAE Quarterly Transactions*, Vol. 5, No. 2, April, 1951, pp. 143–150, illus.

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Machine-shop layout at Sperry Gyroscope Co. utilizes the "colony-type" layout. A large central tool crib contains all machine-shop tools for active production. Emphasis is placed on the proper design of the operator's bench and accessibility to related assembly operations.

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Reference Works (47)

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Rotating Wing Aircraft (34)

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A Look at Tomorrow's Passenger Copters. David A. Anderton. *Aviation Week*, Vol. 54, No. 15, April 9, 1951, pp. 21–24, 26, 27, illus. British survey of future helicopter passenger transport and its related factors, including helicopters presently in the design or production stage, ideal design, heliports, traffic control, and economics.

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wing aircraft, both production and experimental models, including photographs and descriptions; tables of specifications.

Automatic Control for Helicopter. *Interavia*, Vol. 6, No. 2, March, 1951, pp. 147, 148, illus. 1 reference. Operation of the Sperry A-12 gyropilot for helicopters; advantages in commercial and military operations.

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The least-squares curve-fitting method can be applied to the solution of the coefficients of the linear differential equation for the transient response of an aircraft if the input is an arbitrary function of time. The least-squares solution is obtained by means of a Taylor series expansion. The method is simplified considerably if free oscillation data are available.

Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method. James B. Rea. (*Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950.) *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 375–397, illus. 17 references.

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On Diophantine Approximation to Certain Exponential and Bessel Functions. H. Todd. *London Mathematical Society, Proceedings*, Vol. 50 (Series 2), Part 7, May 23, 1946 (Issued March 11, 1949), pp. 550–559. 6 references.

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Investigation of the stability of a system by examining the behavior of its system function in the complex-frequency domain.

An Analog Computer for Flame Gas Composition. William S. McEwan and Sol Skolnik. *Review of Scientific Instruments*, Vol. 22, No. 3, March, 1951, pp. 125–132, illus. 3 references.

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A Low-Frequency Electronic Integrator. B. H. Harrison. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 725*, February, 1951. 29 pp., illus., fold. charts. 6 references. Design, operation, and maintenance of Type 63A D.C. Electronic Integrator developed for acquiring velocity data from measurements of acceleration.

SEAC Demonstrates High Reliability. *U.S., National Bureau of Standards, Technical Report No. 1538*, April, 1951. 9 pp., tables. 1 reference. Operational history and performance evaluation of SEAC.

Visual Presentation of Binary Numbers. E. H. Lenaerts. *Electronic Engineering*, Vol. 23, No. 278, April, 1951, pp. 140, 141, illus. 2 references.

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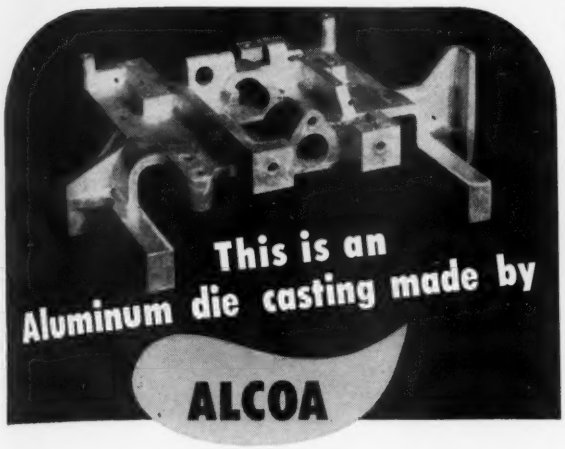
On the Compression of a Cube Between Rough End-Blocks. Bekir Tekinalp. *Istanbul, Technical University, Bulletin*, Vol. 2, No. 2, 1949, pp. 101–110, illus.



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Computation of the forces and deformation of a cube of which the upper and lower surfaces are fixed to end blocks. A procedure is developed for obtaining the displacements and boundary conditions in the cube. Tables show the computational procedure.

Formulas for the Determination of Residual Stress in Wires by the Layer Removal Method. W. R. Read, Jr. *Journal of Applied Physics*, Vol. 22, No. 4, April, 1951, pp. 415, 416, illus. 2 references.

The distribution of residual axial stress in a beam or wire of circular cross section is derived as a function of the moment required to straighten the wire after removal of successive layers of material. Application of the formulas involves two graphic differentiations and integrations of experimental curves.

End Restraints on Truss Members. Harold E. Wessman and Thomas C. Kavanagh. (*American Society of Civil Engineers, Transactions*, Vol. 115, 1950, Paper No. 2419, pp. 1135–1153, Discussion, pp. 1154–1179.) *Washington, University, Engineering Experiment Station, Reprint No. 38*, 1951. 45 pp., illus. 46 references.

Development of a method that is an extension of the moment-distribution method of E. E. Lundquist for analyzing structural frame stability for the calculation of end restraints on truss members and for the effective lengths of compression members under different load conditions. General equations for the stiffness and instability of a bar with elastic restraints are derived. The procedure is applied to the calculation of a specific truss.

A Minimum Energy Solution and an Electrical Analogy for the Stress Distribution in Stiffened Shells. L. A. Goran. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 407–416, illus. 5 references.

The principle of minimum strain energy and the method of Lagrangian multipliers are used to determine the stress distribution in stiffened shell structures. The method handles complex boundary conditions. An electrical network computer is designed to solve the stress problem.

The Centre of Flexure of a Hollow Shaft. A. C. Stevenson. *London Mathematical Society, Proceedings*, Vol. 50 (Series 2), Part 7, December 19, 1946 (Issued March 11, 1949), pp. 536–549. 7 references. Solution of the flexure problem for a hollow tube of circular cross section with an eccentrically placed cavity of circular cross section by determining the conical flexure functions and moment integrals.

Impact on Beams and Plates. J. Lockwood Taylor. *Istanbul, Technical University, Bulletin*, Vol. 2, No. 2, 1949, pp. 17–26.

Basic solution for the concentrated impact loading on a flat plate of uniform section. Shear deflection and rotational inertia are introduced into the equation for the response of a beam to dynamic loading, and the beam solutions are extended to the flat plate with an impact loading symmetrical about a point.

Our Readers Say: Reduced to Simple Language. John Shroeder Carpenter. *Product Engineering*, Vol. 22, No. 4, April, 1951, pp. 238, 240, 242, illus. Simple explanation of the loads and stresses on edgewise loaded plates.

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Analysis of Strain Gauge Measurements on Barracuda Rear Fuselage—Arrested Landing Loading Condition. D. C. Allen. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2390*, 1951 (November, 1945). 5 pp., illus. 2 references. British Information Services, New York. $0.40.

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Flame velocities were measured by the Bunsen-burner method for various fuel-air ratios up to pressures of 50 lbs. per sq.in. at constant temperature to provide an explanation for flame-front oscillation. Such oscillation may cause a blowout in jet engines.

Readers' Forum: Interaction of Flow Pulsations and Flame Propagation. G. H. Markstein. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 428, 429. 8 references.

On Ionization and Luminescence in Flames. E. Sänger, P Georcke, and I. Bredt. *U.S., N.A.C.A., Technical Memorandum No. 1305*, April, 1951. 26 pp., illus. 20 references. Translated from an original German manuscript, received June 17, 1949.

An explanation based upon reaction kinetics is presented to account for the deviation of measured ionization levels obtained through reflection experiments from the values computed assuming chemical equilibrium. The heat transfer to the unburned chemical is also considered.

Method for Determining Pressure Drop of Monatomic Gases Flowing in Turbulent Motion Through Constant-Area Passages with Simultaneous Friction and Heat Addition. M. F. Valerino and R. B. Doyle. *U.S., N.A.C.A., Technical Note No. 2328*, April, 1951. 37 pp., illus., fold. charts. 10 references. Charts for determining pressure drops when heat is added at constant passage-wall temperature.

Report of Progress on Measurements of Friction Coefficients, Recovery Factors, and Heat-Transfer Coefficients for Supersonic Flow of Air in a Pipe. Joseph Kaye, J. H. Keenan, and W. H. McAdams. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 3, April, 1951, pp. 267–277, Discussion, pp. 277–279, illus. 11 references. Measured values; Mach Number range is 1.2 to 2.5.

Readers' Forum: On the Calculation of the Rate of Heat Transfer Through a Laminar Boundary Layer. Arthur N. Tifford and John Wolansky. *Journal of the Aeronautical Sciences*, Vol. 18, No. 6, June, 1951, pp. 427, 428, illus. 6 references.

The Effect of an Arbitrary Surface-Temperature Variation Along a Flat Plate on the Convective Heat Transfer in an Incompressible Turbulent Boundary Layer. Morris W. Rubesin. *U.S., N.A.C.A., Technical Note No. 2345*, April, 1951. 37 pp., illus. 13 references.

Heat Transfer Through Gases at Low Pressures. R. E. Peck, W. S. Fagan, and P. P. Werlein. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 3, April, 1951, pp. 281–287, illus. 13 references.

Experimental study of the heat transfer between two parallel vertical plates. At low pressure the mechanism of heat transfer is molecular motion. The apparatus and experimental techniques are explained; some work was carried out at atmospheric pressure to check the apparatus. Variations of heat transfer and heat-transfer coefficients are plotted against pressure and temperature for air and helium.

The NBS-NACA Tables of Thermal Properties of Gases. *U.S., National Bureau of Standards.*

Table 2.39, Dry Air: Coefficients of Viscosity, η/η_0, ν/ν_0. F. C. Morey. December, 1950. 8 pp., figs. 28 references.

Table 2.42, Dry Air: Thermal Conductivity, k/k_0. R. L. Nuttall. December, 1950. 5 pp., figs. 17 references.

Table 2.44, Dry Air: Prandtl Number, $\eta c_p/k$. Joseph Hilsenrath. December, 1950. 4 pp., figs. 8 references.

Table 4.42, Steam: Thermal Conductivity, k/k_0. R. L. Nuttall. December, 1950. 6 pp. 4 references.

Table 6.39, Helium: Coefficient of Viscosity, η/η_0. R. L. Nuttall. December, 1950. 5 pp., figs. 14 references.

Table 6.52, Helium: Thermal Conductivity, k/k_0. R. L. Nuttall. December, 1950. 5 pp., figs. 7 references.

Table 7.39, Molecular Hydrogen: Coefficients of Viscosity, η/η_0, ν/ν_0. Harold W. Woolley. December, 1950. 5 pp. 2 references.

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Table 11.50, Vapor Pressure of Nitrogen. Harold J. Hoge and Gerard J. King. July, 1950. 5 pp., figs. 13 references.

Table 13.39, Carbon Dioxide: Coefficients of Viscosity, η/η_0, ν/ν_0. R. L. Nuttall. December, 1950. 7 pp., figs. 10 references.

Table 13.42, Carbon Dioxide: Thermal Conductivity, k/k_0. R. L. Nuttall. December, 1950. 5 pp., figs. 13 references.

Thermodynamic Properties of Reactive Gas Mixtures. Ashley S. Campbell. *Franklin Institute, Journal*, Vol. 251, No. 4, April, 1951, pp. 437–452, illus. 2 references. Entropy, heat capacities, and pressure-temperature changes in reactive gas mixtures, and comparison with similar inert systems.

Water-Borne Aircraft (21)

Comparison of Theoretical and Experimental Response of a Single-Mode Elastic System in Hydrodynamic Impact. Robert W. Miller and Kenneth F. Merten. *U.S., N.A.C.A., Technical Note No. 2343,* April, 1951. 26 pp., illus. 6 references.

Readers' Forum: On the Virtual Mass of Water Associated with an Immersing Wedge. John D. Pierson. *Journal of the Aeronautical Sciences,* Vol. 18, No. 6, June, 1951, pp. 430, 431, illus. 4 references.

Wind Tunnels & Research Facilities

High-Efficiency Supersonic Diffusers. E. P. Neumann and F. Lustwerk. *Journal of the Aeronautical Sciences,* Vol. 18, No. 6, June, 1951, pp. 369–374, illus. 10 references. Design of supersonic diffusers with variable throats for wind-tunnel applications; test results; scale effects.

Kerr Cell Photography of High Speed Phenomena. E. M. Pugh, R. v. Heine-Geldern, S. Foner, and E. C. Mutschler. *Journal of Applied Physics,* Vol. 22, No. 4, April, 1951, pp. 487–493, illus. 2 references.

Visible light silhouette photographs of metal jets are obtained by synchronizing, with the jet action, a light source obtained with an electrically exploded wire of peak intensity of 3 to 5×10^8 candlepower and a Kerr-cell shutter. A schematic diagram shows the test setup.

Letters to the Editor: Transmission Line Kerr Cell. J. W. Beams and H. S. Morton, Jr. *Journal of Applied Physics,* Vol. 22, No. 4, April, 1951, p. 523, illus. 1 reference.

A fast-acting Kerr-cell light-shutter arrangement in which almost any liquid showing the Kerr effect may be used. The Kerr constant and dielectric constant are of less importance than in the standard Kerr cell.

Investigation of the Flow Past Finite Wedges of 20 Deg. and 40 Deg. Apex Angle at Subsonic and Supersonic Speeds, Using a Mach-Zehnder Interferometer. D. C. Pack. **With Appendix: Sensitivity and Accuracy of the Interference Method Applied to Pressure Measurements.** E. Groth. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2321,* 1949 (May, 1946). 30 pp., illus. 6 references. British Information Services, New York. $1.40.

Tests in the high-speed tunnel A7 of the Luftfahrtforschungsanstalt, Brunswick, at $M = 0.6$–0.85 and 1.4–2.8. Photographs of the density and pressure throughout the flow field were taken by means of a Mach-Zehnder interferometer. The tunnel arrangement and the optical arrangement are described; the sensitivity and accuracy of the interference method are analyzed.

Compressible Flows. James B. Kelly. *American Journal of Physics,* Vol. 19, No. 4, April, 1951, pp. 237–243, illus. 6 references. Summary of principal optical methods of wind-tunnel testing for compressible flows.

Shock-Wave Shadow Photography in Tunnel and in Flight. I—Three-Dimensional Shock Wave Recorder. II—Shock Wave Photography in Flight. III—Shadow Phenomena of Shock Waves and the Effect of Optical Systems. F. E. Lamplough. *Aircraft Engineering,* Vol. 23, No. 266, April, 1951, pp. 94–103, illus. 2 references.

Application of the three-dimensional shock-wave recorder to open and closed jets; effect of tunnel walls; in-flight photographs of the shock waves developed on aircraft wings at near sonic speeds; contour technique.

Airflow Patterns in the Neighbourhood of Helicopter Rotors. J. Meijer Drees and W. P. Hendal. *Aircraft Engineering,* Vol. 23, No. 266, April, 1951, pp. 107–110, illus. 3 references. Apparatus for smoke-tunnel tests of the flow pattern near helicopter rotors at the National Aeronautical Research Institute (Amsterdam). A cutaway drawing shows the components of the hot-wire smoke generator.

The David Taylor Model Basin. Arthur P. Miller, Jr. *U.S. Naval Institute, Proceedings,* Vol. 77, No. 4, April, 1951, pp. 411–421, illus. Facilities; testing procedures, some test results; model construction.

Low-Temperature Lubrication of Turbojet and Turboprop Engines. Saul Barron. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest,* Vol. 16, No. 4, April, 1951, pp. 16–21, illus. 3 references. U.S.A.F. cold-weather test program and facilities for gas-turbine engines at Ladd and Eglin Air Force Bases.

Woomera; Post-War Progress with British Guided Missiles; The Australian Rocket Range. *Flight,* Vol. 59, No. 2203, April 13, 1951, pp. 429–431, illus.

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Aeronautical Reviews — BOOKS

Servomechanisms and Regulating System Design, Vol. 1

By Harold Chestnut and Robert W. Mayer. New York, John Wiley & Sons, Inc., 1951. 505 pp., figs. $7.75.

It is a pleasure to review a book as well organized as this one is. The book is a much needed contribution to the comparatively new and rapidly growing field of advanced control systems.

The problem of analysis of automatic control systems has been approached in a multiplicity of fashions by personnel in the various fields of engineering. As a result some confusion is extant in the methods of analysis and in the nomenclature used. In this book the symbols and nomenclature that were recently recommended by the A.I.E.E. Feedback Committee are used. The various mathematical procedures, used heretofore in the various fields of engineering, and their interrelationships are shown. Therefore, this book should be of general interest since it provides a common basis for all engineers working in the field of control systems.

In the preface, the authors state that the material contained in the book has been presented to General Electric engineers in the Aeronautical and Ordnance Systems Division and in the technical educational programs. This material has also been presented to graduate students, with widely differing backgrounds and previous training, at the Union College Extension Division. These statements explain at least part of the reasons for the exceptionally good organization and presentation in the book.

A brief review of the development and history of the regulator and servomechanism field up to the present time is presented, and some comments are made on the possibility for future developments in the field of automatic control. Following this, the mathematical basis for analysis and synthesis of control systems is presented. Although not completely rigorous in some of the developments, the presentations of the complex variable, solutions of linear differential equations, and use of the Laplace transform are adequate. The mathematical methods are presented in simple form so that extensive previous knowledge of theory or application is not required. The frequency-response techniques are derived from the classical method of solution of differential equations, as well as from the Laplace transform methods, which facilitates understanding by engineers in any field.

In addition to adopting simple approaches, the authors work through examples that explain the use of the mathematical techniques presented. This presentation is in sufficient detail to permit use of the methods and to impart a knowledge of their interrelations. Circuit theory and impedance concepts, which are aids in the use of the frequency response technique, are also presented. They lead to the concept and methods of determining system stability from roots of the characteristics equations by Routh's Criterion or from a complex plane plot and the use of the generalized form of Nyquist's Criterion.

With an understanding of the first six chapters of the book, the entire literature in the field of control systems is opened to the reader. The remaining chapters of the book deal with the extension and application of these fundamentals to the study of control systems. Typical control elements and their transfer functions are presented, and the transfer functions for a number of physically different forms of control elements and servomechanism motors are described. Combining these elements into complete control systems is discussed, and three types of feedback control systems are presented. The use of the complex plane plot to improve system performance is thoroughly presented, and its use is further simplified by presentation and use of the Bode theorems. Attenuation-phase diagrams are applied to the design of feedback control systems. In the final chapter, comparison of the steady-state and transient performance of servomechanisms is presented by means of a series of charts that show response of an ideal linear system in terms of the open-loop attenuation characteristics necessary to attain this response. Representative problems in the design of multiple-loop and multiple-input feedback control systems add much to a practical understanding of the entire subject matter.

All in all, I believe that this book is excellent for use as a text for advanced undergraduates and graduate students with backgrounds in any field of engineering. It is also an excellent reference for practicing engineers. It is written so that an engineer in any phase of his field can profit by reading all or selected portions of this book.

D. R. SHOULTS
Aro, Inc.
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For information on I.A.S. Library Service Facilities, see page 63

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Laboratory Design

Edited by H. S. Coleman. National Research Council Report on Design, Construction and Equipment of Laboratories. New York, Reinhold Publishing Corporation, 1951. 393 pp., illus. $12.

Research in America has quickly passed through the megabuck stage and is now residing in the kilomegabuck (begabuck, if you prefer) area. It has become big business and hence deserves a big book to guide the construction activities. Mr. Coleman's *Laboratory Design* goes a substantial way toward fulfilling this need. To quote the preface: "In a scientific research organization, facilities are second only to abilities. Notwithstanding this fact and notwithstanding the great growth of scientific research during the past two decades, there has been lacking a reference source of constructive information on laboratories. It is the aim of the present treatise to fill this gap in the literature by presenting authoritative up-to-date advices and essential data on the design, location, construction and equipment of laboratories for research and educational institutions and for the industries."

The book constitutes the report of the Committee on Design, Construction and Equipment of Laboratories of

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the National Research Council. This Committee has a number of esteemed laboratory names on its list, and the authors of the 42 chapters are drawn from the Committee roster and a number of other sources.

The book has the following four major subdivisions: Part I—Materials, Facilities, Services and Equipment—General Discussion; Part II—Teaching Laboratories; Part III—Industrial Laboratories; Part IV—Concise Descriptions of Some Modern Laboratories.

Since the book is the compilation of the ideas of almost 50 authors, complete uniformity of treatment or of ideas is not expected. This is all to the good because it is certain that no one has all the right answers, and it is well to have samples of several of the best ideas at hand.

For any person or organization that is planning, or intends to plan, a laboratory building, the first two chapters under Part III, Location and General Design Features and Interior Arrangement, are recommended as a starting point. There is good, though brief, treatment of the magic "module" as the unit of space and area planning. From there one can go into consideration of the optimum location, assuming there is a choice, or into the details of interior construction, materials, lighting, and ventilation for a reasonable distance or ad infinitum.

It is too much to expect that any executive with a gleam of a new building in his eye is going to copy exactly any other known structure. However, there are numerous detailed descriptions of various research laboratories, both academic and industrial, which provide many sensible ideas and save a great deal of trouble and possibly cost. This is the best collection of information on successful experience in laboratories which the reviewer has been privileged to see.

One deficiency that was noted is that there is very little information on cost. This is probably due to appropriate caution on the part of the authors since costs vary over a great range and are particularly unpredictable now that inflation has reared its ugly head. However, some information on the relative costs of different materials, arrangements, and basic equipment would be useful. The same applies to compilation of information on the minimum and optimum laboratory space per worker for different types of activity. Such information can be obtained from the data of experience of a number of workers in a given total area, but it would have helped to analyze this variable a little more carefully.

There are no sections pointed specifically toward laboratories for aeronautical research. This is expected, however, since purely aeronautical activities probably do not fit, even approximately, into any given mold. Nevertheless, principles of general arrangement of laboratories

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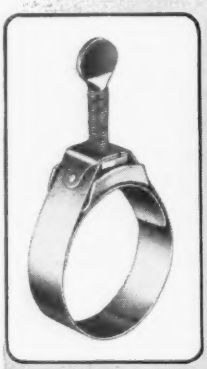

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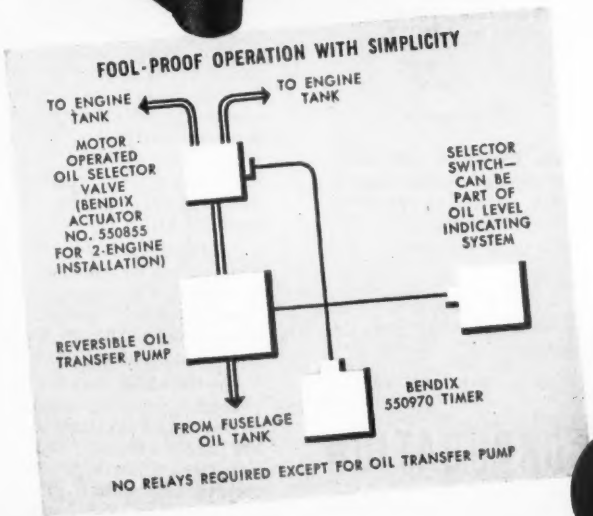
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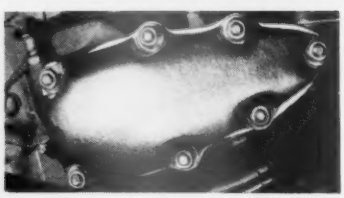

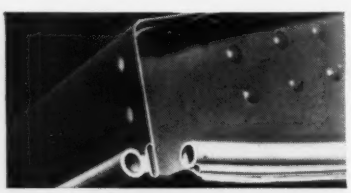

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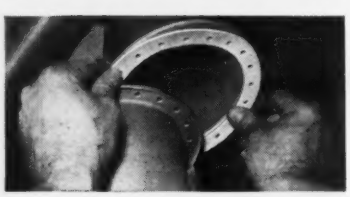

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for work in the basic aspects of the aeronautical sciences are adequately handled.

Despite these minor criticisms, it is an excellent book, beautifully illustrated, and gives, as nearly as possible in 1951, concise and competent guidance to those who have a laboratory.

CLIFFORD C. FURNAS
Director
Cornell Aeronautical Laboratory, Inc.

High-Speed Aerodynamics

By W. F. Hilton. New York, Longmans, Green and Company, 1951. 598 pp., figs. $8.50.

Hilton's *High-Speed Aerodynamics* is a book that is most difficult to review adequately because of the unconventional and uneven choice of material, organization, and presentation. The book essentially represents *High-Speed Aerodynamics* from a personal point of view. The material covered and the unconventional sequence are best seen from a brief review of its contents.

The book is written in four parts. I—Subsonics and Transonics: This part dwells heavily on the phenomenon of shock-stall. II—Supersonics and Hypersonics: Here a review of Ackeret's theory is given together with Busemann's second-order two-dimensional airfoil theory. Three-dimensional problems are also discussed. Hypersonic phenomena are briefly mentioned. III—Wind Tunnels: This part includes some discussion of experimental techniques and basic design principles of wind tunnels. IV—General: This last part is composed of chapters on Thermodynamics; Propellers; Jet Propulsion; Unsteady Flow at Sonic Speeds; and, finally, Elementary Low-Speed Aerodynamics. The mathematical level of the book is kept elementary, since most of the derivations of the equations and final formulas are not given. Many results are presented in excellent graphs and figures. The book appears to be intended for use on specific problems rather than for systematic study, and the audience to which it is apparently addressed includes engineers working on design and development, wind-tunnel workers, etc.

In the reviewer's opinion, the personal point of view of the author is expressed, for example, in the unduly large emphasis on shock-stall and on second-order theory for two-dimensional supersonic flow.

On the other hand, extremely vital problems for high-speed aircraft, such as inlets and skin-friction phenomena, are barely touched; the transonic and hypersonic similarity laws are not mentioned. Wind-tunnel design and instrumentation, however, are treated in more detail and more adequately than is customary in books of a similar scope.

The main shortcoming of the book, in the reviewer's opinion, is the great number of loose statements and explanations, including definitely incorrect statements in some rather important parts. For example, in the discussion of shock-stall it is stated that the thickening of the boundary layer behind the shock increases the skin friction. The opposite is evidently true. To prove a very useful point—namely, the mistake often made in using too sensitive a schlieren system—two schlieren photographs of cones are shown. The perfectly correct shape of the compression zone near the conical tip is explained as being due to the oversensitivity of the instrument. Some of the explanations of shock-wave formation on wings, of the effect of turbulence on shock formation, of shock reflection in the boundary layer and also part of the discussion in the section on thermodynamics appear more confusing than enlightening since they are just at the fringe between right and wrong.

In general, the reviewer feels that the book would have profited a great deal by a careful overall check and review before publication. In this way, the fresh and often ingenious approach of the author could have been preserved and a great deal more accuracy and reliability added. This lack of reliability at the present time makes it rather difficult to recommend the book without cautioning the reader.

Finally, it should also be mentioned that the book is seriously hampered by exaggerated advertising by the publishers, which makes the text appear to be science-fiction.

PROFESSOR H. W. LIEPMANN
California Institute of Technology

Architects of Aviation

By Maurice Holland. New York, Duell, Sloane and Pearce, Inc., 1951. 209 pp. $4.00.

So Away I Went!

By William Bushnell Stout. Indianapolis, The Bobbs-Merrill Company, Inc., 1951. 336 pp., illus. $4.00.

The Airmail, Jennies to Jets

By Captain Benjamin B. Lipsner, As Told to Leonard Finley Hilts. Chicago, Wilcox & Follett Company, 1951. 306 pp., illus. $3.00.

Engineering and Western Civilization

By James Kip Finch. New York, McGraw-Hill Book Company, Inc., 1951. 397 pp., illus. $5.00.

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L'Aviation d'Ader et des Temps Héroïques

By Raymond Cahisa. Paris, Editions Albin Michel, 1950. 342 pp., illus. 780 fr.

Architects of Aviation is written about twelve men representative of those who have made fundamental contributions to the advancement of aeronautics. Some of them, such as Dr. Jerome C. Hunsaker, the late Dr. Alexander Klemin, William B. Stout, the late Charles L. Lawrance, Juan Trippe, and Glenn L. Martin, are widely known through their books, papers, and addresses, through the importance of the positions or offices they have held, through the length of time they have served aviation, or through the honors they have received for their contributions.

Colonel Thurman H. Bane's remarkable work, while in command at McCook Field in Dayton, in combining the 19 sections and 75 branches of the Bureau of Military Aeronautics and the Bureau of Aircraft Production and in laying a solid foundation for fundamental research and development is described in one of the longer chapters. Among the developments taking place under his direction or expedited by the groundwork he laid were the development of landing lights and airport lighting systems by Donald L. Bruner, making night flying possible; the development of aerial photography by Albert W. Stevens; and the development of the parachute by Edward L. Hoffman. The work of these Air Service officers and of Erich Nelson, engineering officer of the Army Air Service Round-the-World Flight of 1924, is included. Edward O. McDonnell, outstanding Navy flyer who in later years influenced aviation as a financier and investment counselor, is also included. Maurice Holland's long and active association with industrial research brought him close to most of the achievements described, particularly the early work at McCook Field. He served there during World War I and up to 1923 and organized and supervised the Industrial Engineering Branch. His book provides a useful and readable record for the growing shelf on American aviation history.

William B. "Bill" Stout's autobiography bears out a description once given of its author, "restless, perpetually creative and completely home spun." In demand as a public speaker since his first lecture in 1907 on the recommendation of Octave Chanute, he has also been a successful newspaper and magazine writer, but he went naturally into engineering, designing commercial, transport, and personal airplanes, automobiles, mechanical toys, and folding transportable buildings. His folding trailers solved many housing problems during World War II for the Air Force in all climates. His designs of a thick-wing cantilever monoplane, a bat-wing-type plane with enclosed cabin, an all-metal Navy torpedo plane, all-metal commercial planes, and roadable airplanes were either successful or far ahead of their time. His Scarab automobile and his Pullman Railplane were typical in other fields. The Ford trimotor plane made possible the passenger service operated by Stout and the freight line operated by Ford, and several of these history-making planes are still in operation. The author is not, as he says on page 243, a big-organization man, and this lends color to his impressions in 1951 of the early days at McCook Field and of work with the Ford organization. In fact, this book has color all the way through.

The first two-thirds of *The Airmail, Jennies to Jets* covers the period from May 14, 1918, to December 6, 1918, providing a most important detailed record by the first Superintendent of the United States Aerial Mail Service. Today's air transportation and the airplane development that partly made it possible owe much to the proving ground of the early scheduled air mail. Captain Lipsner's facts and opinions should be of permanent value in the history of American aviation, particularly to anyone interested in air mail history.

Professor Finch's *Engineering and Western Civilization* is a social and

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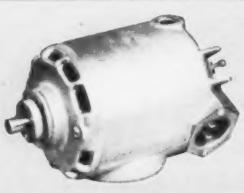

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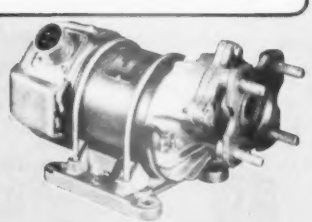

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economic history, correlating advances in all branches of engineering with civilization as it has progressed during the last 5,000 years. As an engineering interpretation of history, the book is unusual, since most technical histories have been written by historians. Although some minor errors were noted in the aviation section, Professor Finch's general conclusions on the effect of the airplane on history and its probable future will probably find agreement in most quarters.

Raymond Cahisa gives most of his time in *L'Aviation d'Ader et des Temps Héroïques* to the period between 1890 and 1914. The book is concerned with heavier-than-air flight, and the emphasis is naturally placed upon French flyers and events. There are 68 pages on Clement Ader. The longest chapter (174 pages) deals with "The Heroic Age," from about 1908 to 1914. The American reader will find it a useful presentation from the French point of view. The photographs are excellent.

MAURICE H. SMITH
Librarian, I.A.S.

Book Notes

AERODYNAMICS

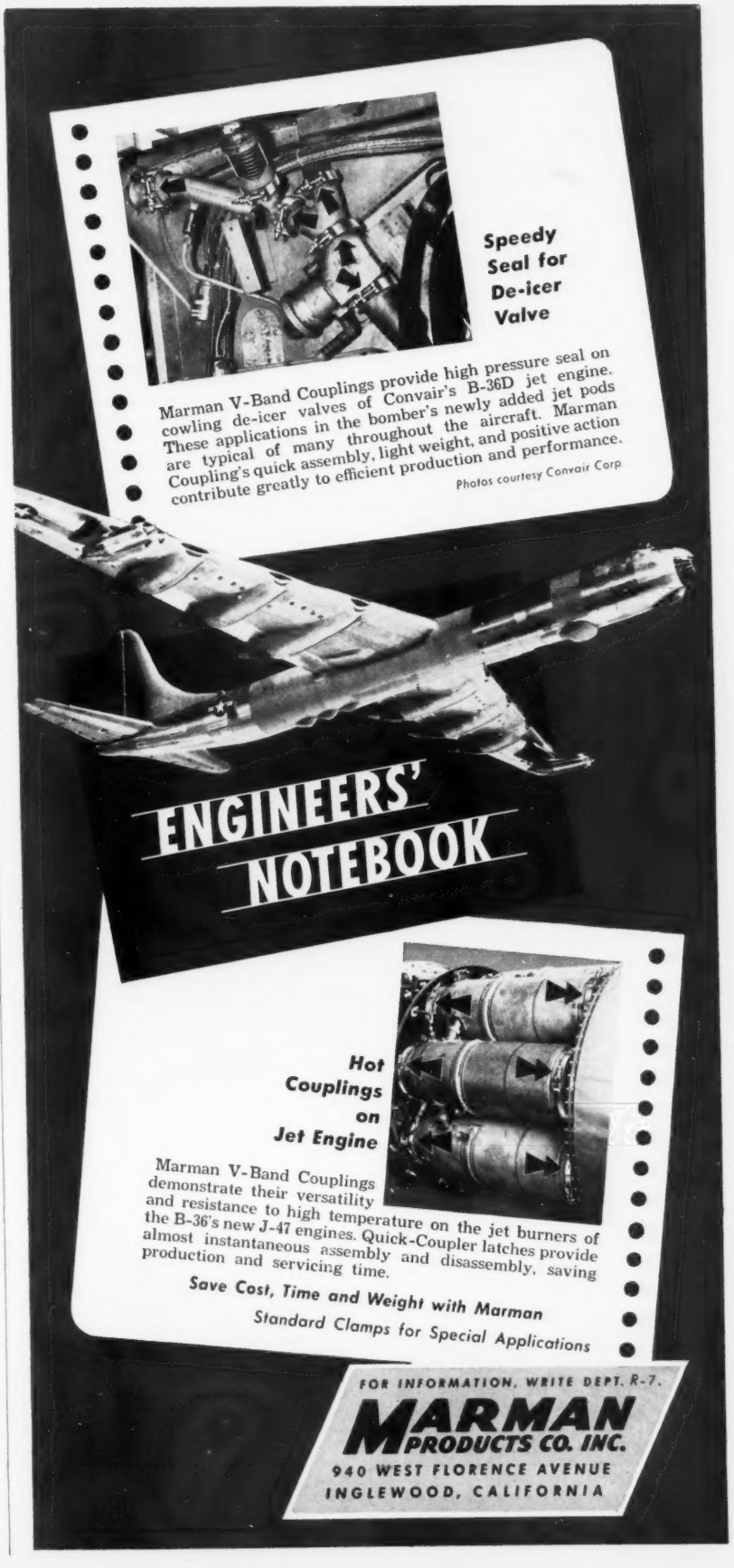
American FIAT Review of German Science. Vol. 5, Applied Mathematics; Part 3, Mathematical Foundations of Fluid Mechanics. Senior Author, Alwin Walther; Coauthors, H. Görtler, R. Sauer, K. Karas, L. Schiller, and K. Wieghardt. Petersburg, N.Y., The O. W. Leibiger Research Laboratories, Inc., 1950. 293 pp. $5.30.

The purpose of this volume is to present a review of German progress in the field of mathematical fluid mechanics between 1939 and 1946. In the Summary by H. Görtler, sources of information used in writing the volume are discussed in detail, including an outline of the contents of the *Göttingen Monograph 1935–1946*. The textbooks published by Prandtl, Eck, Sauer, Weinig, and others since 1939 are also discussed. Dr. Görtler is also the author of Chapters 1, 2, and 3 on Ideal Fluids, Viscous Fluids, and Turbulent Flow. The Dynamics of Gases is discussed by Robert Sauer. Chapter 5, Heat Transfer, and Chapter 6, Wings, Propellers, Pumps and Turbines, are by K. Wieghardt. Hydraulics is discussed by K. Karas, and Dimensional Analysis is discussed by L. Schiller. Dr. Alwin Walther contributes an introduction. The translation does justice to the quality of the material in every way.

This is one of the volumes of the projected 88-volume translated English edition of the *FIAT Review of German Science*, which was produced by outstanding German engineers and scientists at the end of the war in cooperation with the British, French, and U.S. Field Information Agencies, Technical. Investigations and advances, made in Germany between May, 1939 and May, 1946, in the fields of pure and applied mathematics, physics of solids, liquids and gases, hydro- and aerodynamics, nuclear physics, electronics, meteorology and other earth sciences, biology, chemistry, and medicine are reviewed. A complete catalog of the 88 volumes is available from the publisher at $0.25. The translation is published in cooperation with the Office of Technical Services, U.S. Department of Commerce.

ELECTRONICS

Advances in Electronics, Vol. 3. Edited by L. Marton. New York, Academic Press, Inc., 1951. 357 pp., illus., diagrs. $7.50.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Proceedings of the National Electronics Conference, Volume IV (1950). Chicago 19, Ill., National Electronics Conference, 1951. 542 pp., illus., diagrs. $5.00.

Contents: Color Television Standardization, Wayne Coy. What's Behind I.R.E., John V. L. Hogan. Corrugated End-Fire Antennas, Donald K. Reynolds and Winston S. Lucke. New Technique in Microwave Spectroscopy, William E. Good. Properties of Longitudinal Slots in Circular Waveguides, G. E. Feiker and S. C. Clark, Jr. Magnetic Amplifier Voltage Regulator, John L. Wolff. Noise Figure of the Magnetic Amplifier, N. R. Castellini. Magnetic Amplifiers with Orthonol Tape Cores, W. A. Geyger. Dielectric Load Tuning in R-F Heating, Richard H. Hagopian. Measuring Dielectric Properties During HF Heating, Eugene Mittelman. The Electronic Umpire, Richard F. Shea. The Thyratron as a Close-Differential Relay, Jordan Jay Baruch. Electromechanical Pulse Delay Unit, James F. Gordon. Miniaturizing Pentode Amplifiers by Postive Feedback, W. B. Anspacher. Using Conductance Curves in Elect onic Circuit Design, Keats A. Pullen, Jr. Analysis of Twin-T Filters, Louis G. Gitzendanner. Cascading Cathode-Followers to Provide High-Impedance Transformation Ratios, Sydney E. Smith and William J. Kessler. Electrolytic Tank Studies in Designing High Vacuum Tubes, John E. Jacobs and John A. M. Lyon. A Beam-Type Tube That Multiplies, Alexander Somerville. Low-Noise Miniature Pentode for Audio Amplifier Service, D. P. Heacock and R. A. Wissolik. Glass Selection and Production Techniques for X-Ray and Other Tubes, M. J. Zunick and J. B. Gosling. Television in Industrial Applications, J. A. Good. Stereo-Television in Remote Control, H. R. Johnston, C. A. Hermanson, and H. L. Hull. The Genlock—A New Tool for Better Programming in Television, John H. Roe. Reliable Electronic Equipment—A Progress Report, G. B. Devey. Detection of Tramp Metal, C. W. Clapp. Selecting Critical Components for Matched-Channel Radio Receiving System, Harold D. Webb. Recent Lorac Developments, J. E. Hawkins. Flight Path Control, David L. Markusen. Impulsive Radio Interference and Reduction Methods, M. M. Newman. The Electron Optical System of a Permanent Magnet Electron Microscope, John H. Reisner. Electronic Scanning Techniques for Low-Level Circuits, B. R. Shepard. Germanium Photocells, George D. O'Neill. A Multipurpose D-C Amplifier with Reduced Zero-Offset, Will McAdam, R. E. Tarpley, and A. J. Williams, Jr. The Study of Oscillator Circuits by Analog Computer Methods, Han Chang, R. C. Lathrop, and V. C. Rideout. Rosette Principal Strain Computer, C. M. Hathaway and R. C. Eddy. A Versatile Small Scale Analog Computer, James T. Carleton. An Analog Computer for Indeterminate Mechanical Structures, J. P. Corbett and J. F. Calvert. Magnetic Recording with A-C Bias, R. E. Zenner. Recent Design Developments in Electronic Organ Tone Generators, S. L. Krauss and C. J. Tennes. Enclosures and Amplifiers for Direct-Radiator Loudspeakers, Leo L. Beranek. Progress Report on Millimicrosecond Oscillography, Y. P. Yu and P. S. Christaldi. A Six-Channel Cathode-Ray Recording Oscillograph, Warren D. Tilton, Jr. A Portable Projection Oscilloscope, Victor Wouk. A Cathode-Ray Oscillograph for Impulse Testing, W. G. Fockler. Nonlinear Techniques for Improving Servo Performance, Donald McDonald. Electronic Control for Heating Systems, J. M. Wilson. Automatic Control of Inaccessible Terminal Voltages, R. L. Cosgriff and E. H. Gamble. Borocarbon Film Resistors, R. O. Grisdale, A. C. Pfister, and G. K. Teal. Electronic Aspects of Radiation Instruments, E. E. Goodale and R. M. Lichtenstein. Corona Voltage Regulator Tubes for Nucleonics, D. L. Collins. Electronics in Particle Accelerators, T. M. Dickinson and T. W. Dietze. Industrial Electronic Control Design Practices, F. H. Vedder. Electronics in Electric Power Central Stations, A. J. Ward. An Indirect Method of Process Control, Robert G. Durnal. A 20 to 1,000 MC Sweep Oscillator, John E. Ebert and H. A. Finke. A Miniature Crystal Controlled S-Band Signal Generator, W. F. Marshall. A High Resolution Spectrum Analyzer, Theodore Miller and David Sims. Radioactive Snow Gage with Telemetering System, John A. Doremus. Design Characteristics of Air Proportional Counters, Addison C. Sheckler. An Investigation of a Scintillation Counter Using Anthracene Crystals, Bernd Ross.

FLIGHT OPERATING PROBLEMS

A Flier's World. Wolfgang Langewiesche. New York, McGraw-Hill Book Company, Inc., 1951. 278 pp., illus. $3.75.

Wolfgang Langewiesche is an articulate airplane pilot. He makes technical facts clear to the layman, pilot, and engineer, alike. Frederick Lewis Allen says in his foreword to this book that Langewiesche must be a unique link between the designer and the pilot. He is certainly a readable link and difficult to compare with anybody else. The present volume contains six typically good chapters on the art of flying, including one on high speed, one on high altitude, one on ocean flying, and one on instrument flying. Two others deal with What Makes the Weather and Winds That Blow Straight Up. There is a chapter on personal flying, and one on flying in various parts of the United States. A flight from the United States to the East Indies via Europe and the Near East is described in five chapters that are a departure from the usual writing of the author.

INSTRUMENTS

Engineering Metrology. K. J. Hume. London and New York, Macdonald & Company (Publishers) Ltd., 1950. 293 pp., illus., diagrs. $4.00.

The author's object is to provide an introduction to the subject for those in industry concerned with precise measurement in production, inspection, or tool room or standards room work, and a reference for gage designers and production and planning engineers. A second purpose is to provide a textbook for students undertaking study for the national certificate or for the mechanical and production engineering examinations in metrology. Basic principles are discussed in the beginning chapters, proceeding into standards and the manufacture of gages. Following a chapter on optical manufacture and microscopes, the discussion takes up linear and angular measurement, circular division, straightness, flatness and squareness, alignment testing, and surface finish. There are two chapters on screw threads, and the book ends with chapters on gage and instrument design and miscellaneous measurements. There is a bibliography of books and articles. The author is Metrology Superintendent of the de Havilland Engine Co., Ltd.

MATERIALS

Silicate Melt Equilibria. Wilhelm Eitel. Translated from the German by J. G. Phillips and T. G. Madgwick, with the Collaboration of R. B. Sosman, with Revisions and Additions by the Author. New Brunswick, N.J., Rutgers University Press, 1951. 159 pp., illus. $5.00.

This book was first published in German in 1943. The present excellent translation was undertaken because of the need for a thorough and comprehensive text on the principles and diverse phenomena involved in the heterogeneous fusion equilibria in silicate multicomponent systems. The principles of the phase rule in this

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application are important in the consideration of anomalies resulting from undercooling, deficient reaction through coating, and formation of crystal zones in ceramic bodies and glass. The greater part of the book is devoted to binary and ternary systems, with a chapter on quaternary systems and a brief discussion of polynary systems. There are 92 references at the ends of chapters.

The American FIAT Review of German Science, 1939–1946. Vol. 31, General Metallurgy. Translated, Edited, and Published in Cooperation with the Office of Technical Services, U.S. Department of Commerce, by The O. W. Leibiger Research Laboratories, Inc. Petersburg, N.Y., The O. W. Leibiger Research Laboratories, Inc., 1951. 395 pp. $5.30.

Contents: Chemical Physics of Alloys, U. Dehlinger. Crystal Structure of Intermetallic Phases, H. Nowotny. Elastic Properties, W. Köster. Thermochemistry of Metals and Alloys, O. Kubaschewski. Structure of Binary Alloys, E. Gebhardt. Structure of Ternary Alloys, R. Vogel and Th. Heumann. Structure of Quaternary Alloys, A. Schrader. Properties and Crystallization of Metal Melts, E. Scheil. Diffusion in Metals, O. Kubaschewski. Transformations in the Solid State, W. Hofmann. Plastic Deformation, Solidification, Recuperation, A. Kochendörfer. Recrystallization, A. Kochendörfer. Production of Microsections and Etchings for Microscopic Examination of Structures, A. Schrader. Electron-Microscopy, H. Mahl. Structural Determination by X-Rays, W. Hofmann. Strength Characteristics of Metals in Testing and Construction, E. Seibel. Method and Equipment for Strength Analysis, N. Ludwig. Wear Due to Cavitation, H. Nowotny. Nondestructive Testing of Materials, O. Vaupel. Cutting and Machining Tests, H. Schallbroch. Theory of Corrosion, R. Ergang and G. Masing. Stress Corrosion, G. Wassermann. Corrosion Test Methods, W. Wiederholt. About 1,575 references are included in the bibliographies, and there are indexes of authors and subjects.

POWER PLANTS

Gas Turbines and Jet Propulsion. G. Geoffrey Smith. 5th Ed. London, Iliffe and Sons, Ltd.; New York, Aircraft Books, Inc., 1951. 394 pp., illus. $7.50.

First published in 1942, this pioneering book was last revised in 1946. The present edition is larger than the last by 138 pages and aims to present the state of knowledge on the gas turbine as of 1949. Extensive revisions and additions have been made, and new turbojet and turboprop engines and jet aircraft are described. Among the new chapters are those on Canadian and European Turbines, Compounded Units, Ramjets and Pulsejets, Rocket Propulsion, and Turbines for Road Vehicles. The excellent drawings and photographs illustrating previous editions have been increased in this edition to supplement the new material.

PRODUCTION

Plant Layout; Developing and Improving Manufacturing Plants. John A. Shubin and Huxley Madeheim. New York, Prentice-Hall, Inc., 1951. 433 pp., illus., diagrs. $7.35.

The first 125 pages (7 chapters) of this textbook are concerned with economic change and growth, the characteristics of industrial processes, plant location, product design, technological advance, and equipment replacement problems. Chapter 8 (140 pages) discusses in detail the layout of a new plant, and Chapter 9 (95 pages) discusses the revising and improving of existing plant layouts. The topics discussed generally in the early chapters are integrated into the texts of these two chapters. Materials Handling and Industrial Buildings are discussed in two separate final chapters. Dr. Shubin, author of the first 9 chapters, is associated with the School of Commerce, Accounts and Finance of New York University and is an economist and management consultant. Professor Madeheim is associated with the Department of Business Administration, The

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City College of New York and is a consulting engineer.

Ordnance Production Methods. Edited by Charles O. Herb. New York, The Industrial Press, 1951. 534 pp., illus. $1.00.

Methods of production for all types of ordnance are described in detail from observations at various plants during World War II. There are ten sections in the book, covering Small-Arms Ammunition; Shells; Shell Fuses and Boosters; Cartridge Cases and Cartridge Tanks; Bombs, Rockets, and Torpedoes; Machine Guns and Small Arms; Artillery, Anti-Aircraft, and Naval Guns; Gun Mounts; Tanks, Gun Bogies, and Limbers; and General Ordnance Manufacturing. Aircraft armament is liberally covered. The discussions are specific and practical, naming the machine tools used, temperatures, dimensions, details of operations, methods of materials handling, and inspection methods. There are numerous drawings and photographs. The book is made up of 62 articles reprinted from the magazine *Machinery* during the war years.

REFERENCE WORKS

BIBLIOGRAPHIES

The Aeronautical Engineering Index, 1950. New York 21, N.Y., 2 East 64th St., Institute of the Aeronautical Sciences, Inc., 1951. 178 pp. Heavy paper cover. $5.00; $3.00 to I.A.S. members.

The AERONAUTICAL ENGINEERING INDEX for 1950 is the fourth volume in an annual series begun in 1947. It is a cumulation of the abstracts from the monthly issues of the AERONAUTICAL ENGINEERING REVIEW, an official publication of the Institute of the Aeronautical Sciences.

There are 4,231 abstracts, arranged under 51 main subjects and 263 subheadings. There is a classified Table of Contents, and an alphabetical index of 538 entries, in addition to which there are numerous cross-references. There is an index of authors. Under subjects where the number of abstracts is large, the abstracts are further classified. For example, under Fluid Mechanics & Aerodynamic Theory, there are about 200 abstracts; these are further classified under Flow Around Bodies, Flow with Heat, Hypersonic Flow, Shock Waves, Supersonic Flow, Transonic Flow, and Turbulent Flow.

The entire field of aeronautical engineering is covered, including basic research and the design, description, production, maintenance, testing and operation of all types of aircraft, engines, instruments, and accessories. Related aeronautical subjects covered include air transportation, aviation medicine, air law, production methods, meteorology, and navigation. Basic subjects covered include machine elements, materials, mathematics, mechanics, and thermodynamics.

RESEARCH

Symposium on Standardization in Technical Information Services for Government Contractors. Edited by Maurice H. Smith. Chairman, Dr. Eugene W. Scott; Speakers, E. Eugene Miller, Dr. Dwight E. Gray, Col. Albert A. Arnhym, and Dr. Mortimer Taube. (Sherman M. Fairchild Publication Fund Paper No. FF-5.) New York, Institute of the Aeronautical Sciences, Inc., 1951. 44 pp., illus. $1.00.

Present practices and operations and progress toward uniform standards are described in the processing and distribution of 150,000 technical reports issued annually under the national defense research program. The Symposium was conducted by Dr. Eugene W. Scott, Executive Secretary of the Interdepartmental Committee on Scientific Research and Development. The speakers represent agencies handling about 80 per cent of the documents issued. Mr. Miller is Chief, Division of Research Information, N.A.C.A.; Dr. Gray is Chief, Navy Research Section, Library of Congress; Col. Arnhym is Director, Central Air Documents Office; and Dr. Taube is Deputy Chief, Technical Information Service, Atomic Energy Commission. A selected bibliography of 150 references on documentation is included.

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MATHEMATICS

Elliptische Funktionen. F. Tricomi. Uebersetzt und bearbeitet von M. Krafft. Leipzig, Akademische Verlagsgesellschaft, 1948. 315 pp., diagrs. DM 20.50. In German.

PHYSICS

The American FIAT Review of German Science. Vol. 12, Physics of the Electron Shells. Translated, Edited, and Published in Cooperation with the office of Technical Services, U.S. Department of Commerce, by The O. W. Leibiger Research Laboratories, Inc. Petersburg, N.Y., The O. W. Leibiger Research Laboratories, Inc., 1951. 171 pp. $5.30.

Contents: Atomic Spectra, H. Kopfermann. Continuous Spectra, W. Finkelnburg. Molecule Spectra (Infrared), H. Hoyer. Raman Effect, J. Goubau. Energy Transfer by Nuclear Vibrations, K. Schäfer. Electron-Jump Spectra, Th. Förster. Model Tests and Model Investigations on the Molecular Form, H. A. Stuart. Velocity of Sound, H. A. Stuart. Dielectric Constant and Refractive Index, H. A. Stuart. Molecular Light Diffusion, H. A. Stuart. Electric Double Refraction, H. A. Stuart. Flow Double Refraction, H. A. Stuart. Form and Motility of Linear Molecules, H. A. Stuart. X-Ray and Electron Interferences, M. v. Laue. X-Rays, H. Kulenkampff. About 367 references are included in the bibliographies, and there are indexes of authors and subjects.

Quantum Theory. David Bohm. New York, Prentice-Hall, Inc., 1951. 646 pp., diagrs. $10.

The author's purpose is to present the main ideas of the quantum theory in nonmathematical terms, supplementing this qualitative and physical presentation with a broad range of specific applications worked out in considerable mathematical detail. The physical formulation of the quantum theory is discussed in Part I (8 chapters), and the mathematical formulation in Part II (2 chapters). Applications to such simple systems as wave equations for square potentials, the harmonic oscillator, and spin and angular momentum are covered in the 7 chapters of Part III. Chapters 18, 19, and 20 discuss Methods of Approximate Solution of Schrödinger's Equation, Chapter 21, Theory of Scattering, and the final two chapters, Quantum Theory of the Process of Measurement. The author is associated with the Palmer Physical Laboratory at Princeton University.

The Principles of Cloud-Chamber Technique. J. G. Wilson. Cambridge and New York, Cambridge University Press, 1951. 131 pp., diagrs. $2.75.

This monograph is intended primarily for workers who use, or plan to use, cloud chambers or who wish to investigate the potentialities of the cloud chamber as an instrument of precise measurement. Because of the diversity of present practice, details of construction and manipulation are largely avoided, though the later chapters discuss arrangements for photography, basic principles of operation, counter control, and interpretation of cloud-chamber photographs. The technique of precision measurement and materials of construction are compared and evaluated from experience. The beginning chapters cover the condensation process, ionization, and the production and maintenance of supersaturation. The author is Senior Lecturer in Physics at the University of Manchester.

THERMODYNAMICS

Thermodynamics. 2nd Ed. George A. Hawkins. New York, John Wiley & Sons, Inc., 1951. 563 pp., diagrs. $6.50.

This engineering textbook was first published in 1946. The present edition is larger by 127 pages and includes much new material. The chapters on The First Law of Thermodynamics; The Second Law of Thermodynamics and the Carnot Cycle; Available Energy, Unavailable Energy, and Entropy; Mixtures of Ideal Gases and Vapors; Flow of Gases and Vapors Through Nozzles and Orifices; and General Thermodynamic Equations, have been completely rewritten. Significant minor changes have been made in the chapters on Fundamental Concepts; Solids, Liquids and Gases; The Ideal or Perfect Gas; The Gas Turbine and Jet Propulsion; and Introduction to Heat Transfer. A new table on the thermodynamic properties of air has been added to the appendix. The author is a Professor of Thermodynamics at Purdue University.

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Control Design Engineers—Graduate engineers with design experience in servomechanisms and hydraulic and electric controls to coordinate design of unique nozzle contour control and complicated valve configuration control systems for supersonic wind tunnels. Please submit résumé giving education and details on control design experience. Address: Head Instrumentation Engineer, Sverdrup & Parcel, Inc., Consulting Engineers, Syndicate Trust Building, St. Louis 1, Mo.

Instrumentation Design Engineers—Graduate engineers with experience in the design of instrumentation for supersonic wind tunnels. Please submit résumé giving education and details on instrumentation design experience. Address: Head Instrumentation Engineer, Sverdrup & Parcel, Inc., Consulting Engineers, Syndicate Trust Building, St. Louis 1, Mo.

Aircraft Accessory Specifications Engineer—Graduate engineer to direct preparation of aircraft accessory specifications. Excellent opportunity for man with specifications experience. Please direct reply to AiResearch Manufacturing Company, Preliminary Design Engineering Department, 9851 Sepulveda Blvd., Los Angeles 45, Calif.

312. Teaching—Large engineering college in Southwest has opening on aeronautical engineering staff for a man to teach courses in high-speed aerodynamics and to participate in aerodynamics research.

309. Analytical Engineer—Work includes analysis of aircraft propellers dynamics, control, and vibrations. Experience with control theory, aircraft power plants, and servomechanisms helpful. Technical graduate required—mechanical, electrical, or aeronautical. This position affords an opportunity to assume responsibility in a permanent expanding organization. In reply state age, education, experience, present employment and salary expected.

300. Design Engineer "A" and Design Engineer "B"—Responsible positions requiring 3 to 5 years' experience in mechanical design of aircraft quality, preferably in gas turbines or similar type machines. Must be capable of working from design specifications in making layouts of complete parts or components including sheet-metal construction, taking into consideration manufacturing costs, weight, stress, heat, material properties, mechanics, dynamics, and production problems.

293. Communications Supervisor—Possessing air-line background, capable of being in full charge of operations communications program and electronics research and development in small air line.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

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310. Aeronautical Engineer-Teacher—Desires position in teaching or research. Twelve years' teaching experience in aerodynamics and related subjects. Four years in design and operation of supersonic wind tunnels at high and low pressures. Completing advanced studies in fluid mechanics and aerodynamics this summer. Will be available this fall. Locations preferred: South, Southwest, or West Coast.

308. Aeronautical Engineer—Age 26. Desires position involving flight-test application of jet power plants and/or rocket engines. M.S. in Aero.E. Excellent scholastic and work record. Two and one-half years of research with transonic and supersonic wind tunnels, liquid propellant rockets, and jet-engine problems. Two years as navigator in Air Force.

306. Mechanical Engineer—Would resign responsible position in industry for opportunity to teach in college. Master's Degree in M.E. Seven years' experience in experimental engineering, research and development of propulsion systems—e.g., reciprocating, gas-turbine, and rocket engines. Diverse analytical work; administrative experience.

305. Aeronautical Engineer—M.S. in Ae. and Me.E., 1924. Research, preliminary design, development. Past experience includes: Consulting Engineering (research, coordination of new developments), Project Engineer, Aerodynamics Engineer, Research Engineer, and Chief Design Engineer.

304. Engineer—M.E., M.S., 7½ years' experience in servomechanism and aerodynamic analysis and development. Directed analog computer studies. Expert in analyzing overall system dynamics.

303. Aeronautical Engineer—N.Y.U., 1934. Has held positions as designer, project engineer, chief aerodynamicist, and acting chief engineer. Experienced in wood, dural, and magnesium-alloy aircraft design; general aerodynamics, propeller controls, helicopter design, and various subordinate facets of aeronautical engineering. Desires connection in executive capacity requiring versatility with experimentally minded organization.

302. Aeronautical Engineer—(Industrial Option), B.A.E., New York University, 1949. One year's experience in machine shop and tool design (jigs, fixtures, and machine tools). Worked on U.S. Army Corps of Engineers development contract, designing mechanical operating mechanisms. Experience in aircraft design, including original layouts, detailing and modifications of existing designs. Age 25. Location—New York or vicinity.

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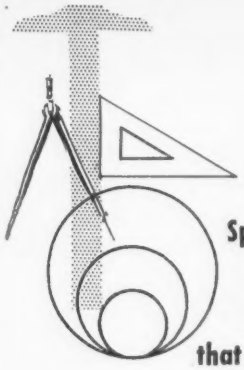

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Index to Advertisers

A

Acushnet Process Company 46
Aeronautical Engineering Catalog 93, 96
Aeronautical Engineering Review 93
*Airborne Accessories Corporation 45
Allegheny Ludlum Steel Corporation 37
Allison Division, General Motors Corporation 69
Aluminum Company of America 87, 93
*American Steel & Wire Company, United States Steel Corporation Subsidiary 91
Arma Corporation, American Bosch Corporation Subsidiary 53

B

B. H. Aircraft Company Inc. 52
Bardwell & McAlister, Inc. 50
Bell Aircraft Corporation 105
Bendix Aviation Corporation
*Bendix Products Division 34
*Eclipse-Pioneer Division 74
Pacific Division 99
*Scintilla Magneto Division 83
Bircher Corporation, The 48
Bridgeport Thermostat Division, Robertshaw-Fulton Controls Company 65
Bunhill Publications Limited 87

C

Cal-Aero Technical Institute 87
*Chicago Metal Hose Corporation 2
*Clifford Manufacturing Company Division, Standard-Thomson Corporation 39
Consolidated Vultee Aircraft Corporation 110

D

Doelcam Corporation 48
Douglas Aircraft Company, Inc. 58, 59
Dow Chemical Company, The, Magnesium Department 33
Dow Corning Corporation 100

E

*Eclipse-Pioneer Division, Bendix Aviation Corporation 74
*Electrical Engineering and Manufacturing Corporation 51
*Electrol, Incorporated 54

F

*Fairchild Engine and Airplane Corporation, Stratos Division 112
Fulton Sylphon Division, Robertshaw-Fulton Controls Company 65

G

*General Electric Company, Apparatus Department 47
General Motors Corporation, Allison Division 69
G. M. Giannini & Company, Inc. 50
B. F. Goodrich Chemical Company 62
Goodyear Tire & Rubber Company, Aviation Products Division 1

H

Hamilton Standard Division, United Aircraft Corporation 110
*Heli-Coil Corporation 67
Holley Carburetor Company ..... Inside Front Cover
Hydro-Aire, Inc. 94

I

Imperial Pencil Tracing Cloth, Keuffel & Esser Company 57
*Industrial Sound Control, Inc. 45
International Nickel Company, The 55

J

*Jack & Heintz Precision Industries, Inc. 41

K

Keuffel & Esser Company, Imperial Pencil Tracing Cloth 57
Walter Kidde & Company, Inc. 71
Kollsman Instrument Corporation 101

L

Lamb Electric Company, The 102
G. H. Leland Inc. 104
Lockheed Aircraft Corporation 98
Lord Manufacturing Company 57

M

Marman Products Company Inc. 103
Glenn L. Martin Company, The 89
Minneapolis-Honeywell Regulator Company 106

N

North American Aviation, Inc. 105, 106
Northrop Aircraft, Inc. 50

O

Oakite Products, Inc. 107

P

Pacific Division, Bendix Aviation Corporation 99
Pacific Scientific Company 61

R

Reid Division, The, The Standard Products Company 72
Republic Steel Corporation
Alloy Steel Division 85
Steel & Tubes Division 4
Resistoflex Corporation 43
Rigidized Metals Corporation 82
Robertshaw-Fulton Controls Company, Fulton Sylphon Division and Bridgeport Thermostat Division 65
*Rohr Aircraft Corporation 81

S

Sandia Corporation 93
*Scintilla Magneto Division, Bendix Aviation Corporation 83
Skinner Electric Valve Division, The Skinner Chuck Company 87
*Sperry Gyroscope Company, Division of The Sperry Corporation ..... Inside Back Cover, 110
Standard Products Company, The, The Reid Division 72
*Standard-Thomson Corporation, Clifford Manufacturing Company Division 39
Stewart-Warner Corporation ..... Back Cover
*Stratos Division, Fairchild Engine and Airplane Corporation 112
Surface Combustion Corporation, Aircraft-Automotive Division 76, 77

U

United Aircraft Corporation, Hamilton Standard Division 110
United States Aviation Underwriters Incorporated 50
United States Rubber Company 79
*United States Steel Corporation, American Steel & Wire Company 91

V

Vellumoid Company, The 87

W

*Wittek Manufacturing Company 9

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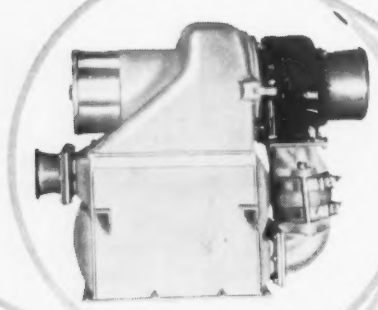

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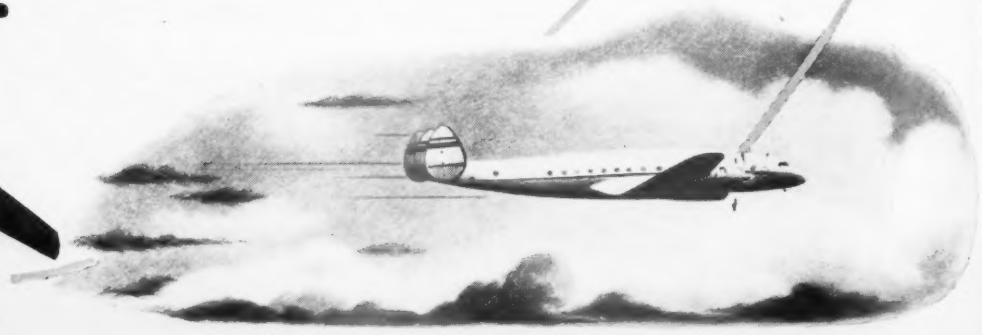

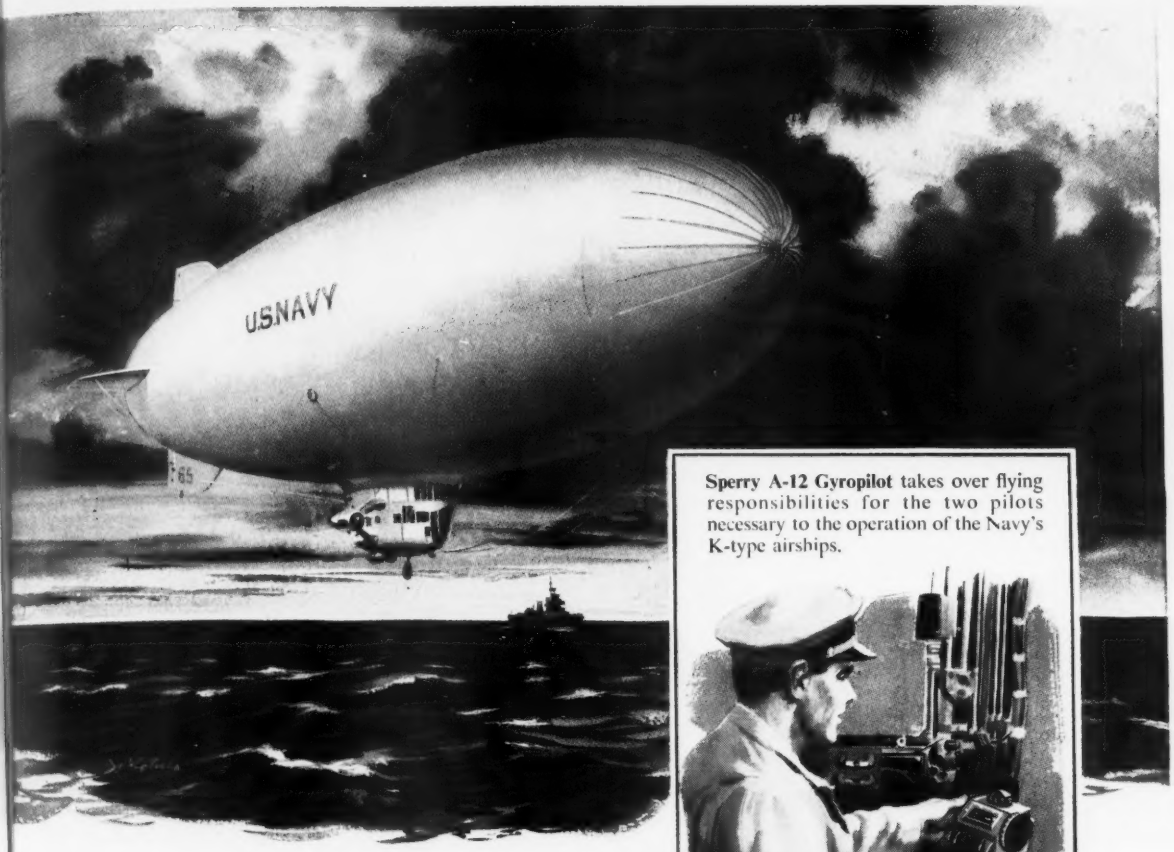

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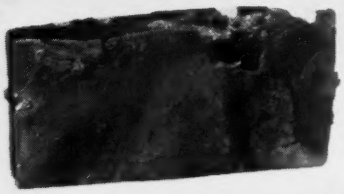
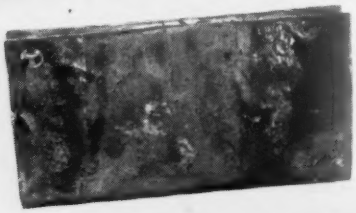


Shown above: a high temperature alloy after suspension in a combustion gas stream for 232 hours. Temperature was in excess of 2200°F. and there was actual flame impingement on the metal itself. The effects of intergranular corrosion and oxidation under such conditions are obvious.



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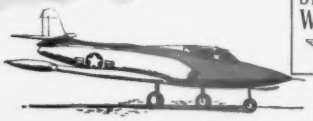

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